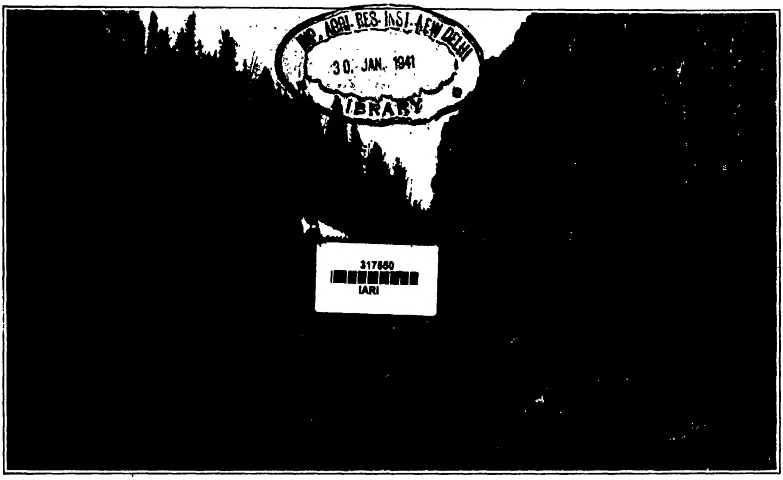
SCIENTIFIC AMERICAN SUPPLEMENT

[...ME LXXIX ...ER 2035] NEW YORK, JANUARY 2, 1915 [10 CENTS A COPY $5.00 A YEAR]



The Golden Gate Road, near the entrance to Swan Lake Basin.

Cleopatra Terrace, formed by water from the Diana Spring.

THE GEOLOGY OF THE YELLOWSTONE NATIONAL PARK.—[See page 7.]

Actual Instances of Dual Personalities—I*

Cases in Real Life That Rival the Wildest Fiction

By Edward Tyson Reichert, M.D., Sc.D., Professor of Physiology in the University of Pennsylvania

The noted English author, Mr. H. G. Wells, was asked, "What is the first step toward literary production?" and he is accredited with the reply: "It is imperative, if you wish to write with any power or freshness at all, that you must utterly ruin your digestion." Perhaps in such a light the originality of the stories of "Dr. Jekyll and Mr. Hyde" and "The Case of Becky" may suggest to some of you the outpourings of abnormal minds, but we find in the histories of the lives of some who have lived before or with us abundant inspiration for such fiction.

When we speak of an individual's personality we have reference to the sum or totality of his mental traits, which traits are expressions of correlations of the past with the present, and not only of his individual past, but also of the lives of ancestral generations which have left their impression on his mental processes. Personality is a manifestation of an extremely complex aggregate of interassociated and interacting mental states—a combination that is so plastic that one or more of the components may become suppressed or exaggerated, and thus transiently or permanently impart to the individual mental characters that are more or less at variance with his recognized identity.

All are aware of the transitional character of our personalities in our every-day lives, as is expressed especially by our variable moods; by the duplicity of personality of the habitual one-day saint and six-day sinner; by the ease with which the actor assumes different personalities, associating with each such traits as characterize the subject; and by the changes brought about by intoxicants—the quiet, kind, loving, moral, cultured man, becoming quarrelsome, brutal, lewd, profane, and utterly lacking in the high ideals that characterize his normal life. We know too that in somnambulism, delirium and certain hysterical states the individual may exhibit mental traits which in many respects are markedly or wholly different from those which typify his normal life; that hasheesh and certain other drugs may produce in the subject a delusion of an existence of a double personality, that is, a sense of having two mental lives which may hold communication; that in certain forms of insanity the individual has the belief of a dual mental and physical existence, even becoming obsessed with the delusion that he is not himself but his double; and that the mental life of normal, hypnotic and narcotic sleep is usually quite different from that of the waking state. But none of these instances is to be included in the category of dual personality because in each there is merely a single personality that has become modified in normal or abnormal ways, whereas in cases of dual personality there are two mental individuals belonging to one body, both sane, each having self-consciousness, and each having its own characteristic mental life.

There can be no question of a close relationship between the psychic states of somnambulism, hysteria, delirium and insanity with those of dual personalities, and it may not always be possible to definitely differentiate them. Where insanity begins and sanity ends no one knows—who can tell whether or not certain people are sane or insane? Similarly, where modifications of a single personality end and dual personalities begin no one can say, yet in both instances there are well-defined types that are so definitely characteristic that we can declare positively that there is one or the other. It is such types that must be studied at the outstart if we are to have clear conceptions of class distinctions and understand the psychology of these extraordinarily interesting cases of two different minds belonging to one body.

Typical cases of dual personality are characterized by the existence of two distinct, sane, self-conscious mental lives belonging to one body. The change from one personality to another is usually abrupt, without obvious cause, and commonly following a period of loss of consciousness, usually sleep, which commonly is long and profound. Upon the return of consciousness there exists a partial or complete loss of memory of the knowledge that particularized the individual's life, this loss being associated with a change of character, so that the subject is to all intent and purposes another mental individual, having a different memory, will, disposition, intellectual powers and habits of mind and body. The acquired personality or secondary state may have no recognition of the existence of the primary or normal state, or *vice versa*; its mental and physical lives may be so entirely different from those of normal life that if reversion occurs to the primary state his secondary state may, as it were, be completely blotted out, so that mental existence is resumed where it ceased when the secondary state appeared, the subject having no knowledge of his life in the interim. In some instances there occurs repeated alternation of the two personalities, and in such cases one personality may at once, or in the course of time, recognize the existence of the other, the subject becoming conscious of a dual mental existence, eventually blending the two, or adopting one or the other permanently, and not infrequently the secondary, or supposed secondary, state. Sometimes there appear multiple personalities, that is, as many as ten or more personalities may be developed, one succeeding another, each differing from the others, each being as characteristic as though the individual had been as many times reborn. And so one might go on indexing these varied and uncanny manifestations of mental life which seem more like freaks and monstrosities of the imagination than actualities of life. Perhaps as many as forty cases of dual and multiple personality have been reported, some of which have been republished time and again, yet they are almost unknown even to the medical profession. Undoubtedly a very large number have existed, and many of the unfortunate subjects found lodgment in insane asylums and prisons.

Turning our attention now for a few minutes to fiction, and first to Robert Louis Stevenson's story of Dr. Jekyll and Mr. Hyde, Dr. Jekyll is described as a large, well-made, smooth and handsome-faced man of fifty, with perhaps something of a slyish cast, but with every mark of capacity and kindness, and who cherished sincere and warm affections. He was a connoisseur, inclined by nature to industry, and fond of the respect of the wise and good. The worst of his faults was a certain impatient gayety of disposition, such as has made the happiness of many, but such as he could not reconcile with his imperious desire to carry his head high and wear a more than commonly grave countenance before the public. Hence, while he indulged he concealed his pleasures, hiding them with an almost morbid sense of shame, and standing committed to a profound duplicity of life. He saw that two natures contended in the field of consciousness and he conceived of the separation of these natures by taking a drug, and of recombining them by an antidote.

Upon taking the potion, agonies were caused which swiftly subsided, and as if out of a great sickness he came to himself in the form of Mr Hyde, a man tenfold more wicked than his primary self and sold a slave to his original evil. As Mr. Hyde he was dwarfish and gave the impression of deformity without namable malformation. He had a displeasing smile and bore himself with a sort of murderous mixture of timidity and boldness. He spoke in a husky, whispering, and somewhat broken voice, and his manner aroused disgust, loathing, and fear. He seemed hardly human and was inherently malign and malicious, taking pleasure in the infliction of every degree of torture. He had the name of Satan written on his face. Mr. Hyde, drinking the antidote, cried, reeled, staggered, clutched at the table, staring with injected eyes and gasping with open mouth, pale and shaken and half fainting, was transformed to Dr. Jekyll. The two natures had memory in common, but all other faculties were most unequally shared between them.

Transitions from one state to the other were frequent, and in time Dr. Jekyll, like those of us in everyday life who habitually give way to evil inclinations, lost hold, as it were, of his original and better self, and became slowly incorporated with his secondary or worse self in the form of Mr. Hyde. He soon came to a realization that he had to choose between the two, and choosing the better, he for two months was Dr. Jekyll. Then, in an hour of moral weakness, he again swallowed the transforming potion, and instantly the spirit of hell awoke and raged in him, and again was he the moral monster, Mr. Hyde.

"The Case of Becky," while presenting certain features in common with those of Dr. Jekyll and Mr. Hyde, is in its manifestations of the secondary state and in certain other respects quite different. The story of Dr. Jekyll and Mr. Hyde belongs to the category of drug fiends we read of from time to time in the daily press; but "The Case of Becky" is one of dual personality, and the conceptions of the author are well founded in histories of cases in life which are even more weird and interesting, and seemingly improbable.

In normal life the person of Becky was known as Dorothy. Dorothy, it will be recalled, was the stepdaughter of an unscrupulous, itinerant hypnotist. She was made by him a hypnotic subject, and grew up amid surroundings such as would naturally tend to develop in a very sensitive girl abnormal mental states. She in time fled in terror from her degenerate and conscienceless stepfather, to be found after some years in a sanitarium, where we are made familiar with her dual lives. As Dorothy, she was a highly sensitive, charming and lovable young woman; sweet tempered, fond of reading, and with exemplary habits of mind and body. At times upon awaking from a short sleep she would exhibit a personality which was the very antithesis of the normal. In this state she was known as Becky. She was quarrelsome, disagreeable, used coarse language, was profane, tore her clothing, and took great delight in annoying those about her, and played all sorts of disagreeable tricks upon her primary self, which appeared to her as the person of another individual, hiding and destroying things which she imagined belonged to this hated person

Mr. Belasco, in the staging of "The Case of Becky," showed remarkable skill Dorothy was a very impressionable girl who, because of abusive treatment and repeated subjection to hypnosis by her stepfather, had her mind so peculiarly affected as to become a victim of self-hypnosis and to lead to the development of a second personality entirely different from her normal. After the appearance of the second personality an alternation of the primary and secondary states took place for years, until finally, under the care of an expert neurologist, she was, through hypnosis restored to her normal self. Such cause, effect and cure are wholly in accord with the facts of science, although perhaps exceedingly few of the audience, and very few critics, looked upon them as being otherwise than entirely imaginative.

What seemed to be the most vulnerable feature of the presentation was Dorothy's consciousness of the presence of her stepfather in some way other than by her ordinary senses—in some occult manner, such as by telepathy, that is, by an influence of one mind over another at a distance by other than the normal channels of communication. But this very point, seemingly small and unimportant to the lay mind, was not overlooked by so skillful a stage craftsman. Those who followed the play with discernment will recall that at a moment before Dorothy appeared on the stage in a self-hypnotic state her stepfather, who was unseen at the time, had coughed loudly and in a strikingly peculiar way—a cough which we are supposed to understand was heard throughout the sanitarium. It was this cough which was intimately related to the horrors of her girlhood, though not consciously recognized by Dorothy, that so affected her peculiarly sensitive and abnormal mind as to throw her into hypnosis. In this condition she was en rapport with her stepfather, extremely sensitive to his presence, and almost wholly submissive to his will. Even in the hypnotic state she has some consciousness of her well-nigh helplessness and the perils that encompassed her in the presence of her stepfather. To dissipate the tendency to self-hypnosis and prevent the recurrence of the secondary state by hypnotic suggestion, in accordance with the play, may seem to be visionary, yet it is entirely consistent with the facts of science. The presentation of the dual character was remarkably true to life.

Turning now from fiction to strange stories from life, we find that the essential features of "The Case of Becky" have their counterpart in the history of the case of Miss Beauchamp, which was published by Dr. Morton Prince ("The Dissociation of Personality," 1906). The subject was a person in whom three personalities spontaneously developed, each being distinctly different from the others in trains of thought, views, ideals, temperament, acquisitions, tastes, habits, experiences and memories. Only one of the three had any inherent knowledge of the others, and the other two had no knowledge of each other or of the first except such as had in time been obtained by inference or by information from other people. Suddenly we find one personality vanishes and another appears in kaleidoscopic succession, each being ignorant of what was said or done or where she was while in the immediately preceding personality. For six years these three personalities played a remarkable and almost unbelievable comedy of errors, making their entrances and exits in a most inexplicable way, each for a time playing her part, each being as individualized mentally and physically as though there were three persons having quite different personalities.

Miss Beauchamp is described as having been a nervous, impressionable child, given to day-dreaming, living in

* A lecture delivered at the University of Pennsylvania, December 19th.

her imagination, unduly influenced by her imagination, living in a land of idealism, and seeing people not as they are but as she imagined them to be, and lacking in true conceptions of her environments She was intellectually keen and fond of books, and she idolized her mother, who, however, was devoid of affection for her, the effect of which was to make her morbidly reticent and live within herself and her imagination. When eighteen years of age a nervous shock played the principal role in the development of the remarkable personalities that for some years encompassed her life At twenty-three she was a college student, ambitious, over-conscientious, mentally and morally stubborn, very nervous, a neurasthenic of an extreme type, and a continual sufferer mentally and physically, becoming worse, and ultimately unfitting her for work

In the course of time two personalities developed which came to be distinguished as Sally and the Idiot The three personalities (Miss Beauchamp, Sally and the Idiot) were so different as to suggest the designations The Saint, The Woman and The Devil

Inasmuch as Miss Beauchamp was a physical wreck, it might naturally be assumed that her bodily ailments would be carried into her other states, so that notwithstanding great changes in mental traits her bodily traits would continue the same But this did not occur, thus showing in an extraordinarily impressive way the potent influences of the mind over the body While Miss Beauchamp was always ill, always suffering, always physically weak and incapable of more than very little physical and mental exertion, the Idiot showed a markedly lessened neurasthenia and was capable of physical and mental exertion much beyond the powers of Miss Beauchamp, yet with distinctly less capacity than Sally As Sally, the Devil, she was a stranger to illness and had remarkable physical endurance knowing neither fatigue nor pain While in the state of Sally she would take long walks, far beyond the physical strength of Miss Beauchamp, and then suddenly Sally would vanish and the body be returned to Miss Beauchamp, who would come to herself in a state of utter exhaustion notwithstanding that only a few moments before, as Sally, there was physical vigor

Miss Beauchamp and the Devil in their physiological and moral tastes, moral characteristics and acquisitions were almost wholly antipodal The kinds of food and drink liked by one were disliked by the other Miss Beauchamp's appetite was poor, she cared little for the pleasures of the table never used vinegar or oil, and was very fond of ice cream and broths, etc The Devil had a good appetite, enjoyed the table, used freely vinegar and oil, never ate ice cream or broths, etc Miss Beauchamp wore her hair low and her clothing loose and was fond of church and devotional books The Devil wore her hair high and her clothing tight, and never voluntarily entered church or read devotional books Miss Beauchamp was patient considerate of others, amiable, hated sewing, and was very fond of children The Devil was most impatient, most inconsiderate, unamiable, given to rages of violent temper, liked sewing and looked upon children as a great nuisance Acquisitions of Miss Beauchamp were often not possessed by the Devil and those of the latter not often by Miss Beauchamp And so in very many ways one personality was the antithesis of the other

Sally is described as having a character trains of thought, memories, perceptions, acquisitions and mental traits generally which were quite different from those of Miss Beauchamp Sally claimed that she knows what Miss Beauchamp thinks, says, writes and does, sees what she sees at the time, and not as knowledge afterwards acquired Curiously enough, while Miss Beauchamp could hide absolutely nothing from Sally she was absolutely without knowledge of the existence of Sally, and Sally, while recognizing the existence, thoughts and so on of Miss Beauchamp, did not associate Miss Beauchamp with herself or her body, but imagined her to be another individual Sally had a jealous hatred of Miss Beauchamp, and remarkable and almost incredible were the pranks, torments and terror to which Miss Beauchamp was subjected The personalities of Miss Beauchamp and Sally frequently alternated A favorite form of Sally's amusement was to suddenly vanish and restore the body to Miss Beauchamp under conditions that would give rise to great mental and physical suffering Sally would write most annoying letters to Miss Beauchamp and she had a most subtle way of stating just enough to cause Miss Beauchamp's imagination to run riot and to fancy all sorts of things, and generally to create a state of mind full of apprehension or even terror Sally would make engagements which she knew Miss Beauchamp could not keep and often Miss Beauchamp would awake to find that she had unknowingly done something entirely different from that which she had contemplated Miss Beauchamp's promises were broken and engagements were made which were objectionable, or even of such a character as she could not in honor keep Sally would write letters exposing the private affairs of Miss Beauchamp, and by distorting exaggerating and deliberately lying she caused the keenest sense of mortification and increased the illness of Miss Beauchamp by the intense anxiety

Sally took advantage of Miss Beauchamp's carelessness about the care of money and many were the torments to which the latter were subjected One day Miss Beauchamp was sorely worried over the mysterious disappearance of some money Sally had hidden it and written a note to Miss Beauchamp, which was received a day later, telling Miss Beauchamp that she was too negligent and incapable of taking proper care of money, and that she would accordingly be put on an allowance of ten cents a day with which to amuse herself For some time thereafter Sally doled out sums of two five or ten cents and then would vanish giving back the body to Miss Beauchamp

For two years this extraordinary and almost incredible play of comedy farce and drama of different personalities in one body went on in alternation

Miss Beauchamp was repeatedly hypnotized by Dr Prince and in the course of time there developed a half-hypnotic state in which there occurred a personality different from the other three She in this state had a full knowledge of the events of the past six years She now seemed to be without the morbid idealism and impressionability so strongly marked in the personality of Miss Beauchamp, and was also without the melancholy sadness and weariness and was less nervous and humble She was light-hearted natural and physically strong and possessed greater spontaneity and intellectual grasp This personality appeared to be the fused personalities of Miss Beauchamp and the Devil a personality that had lost the morbid emotional idealism of the former and the impishness, temper and willfulness of the latter

Naturally the question arises as to which, if any, of these personalities is to be regarded as the real Miss Beauchamp Dr Prince answered this question by showing the real Miss Beauchamp is not the Miss Beauchamp we met at the beginning of our recital, but the fused personalities of Miss Beauchamp and the Idiot be brought about and rendered permanent by hypnosis The personality of Miss Beauchamp as we first knew her was like the personalities of Sally and the Idiot, a dissociated or detached mental state, the other mental states being for the time latent or submerged What became of Sally? The mental state represented by Sally seems to have been a subconscious state that became dominant because of the splitting of the primary self into two parts one part becoming suppressed The union of the personalities of Miss Beauchamp and the Idiot gave rise to a personality of such potentiality that the personality represented by Sally was submerged in subconsciousness The personality of the real Miss Beauchamp after a period of vacillation had continuous existence, and Miss Beauchamp was thereafter a mentally and physically strong individual

In the case of Miss Beauchamp, it will be recalled that while Sally had full knowledge of Miss Beauchamp and the Idiot, the Idiot had only a scrappy knowledge of Miss Beauchamp and no knowledge whatsoever of the existence of either Sally or the Idiot In the case about to be referred to, the secondary personality, unlike Sally, had no knowledge of the primary state, nor had the primary state any knowledge of the secondary The secondary personality curiously enough, played pranks similar to those of Sally, but not upon her own person

(To be continued)

Odessa, the Grain Port of Russia

ODESSA is one of the most important seaports of Russia ranking, by reason of its population and its foreign trade, after Petrograd Moscow and Warsaw Since it was founded in 1794 near the ruins of a Turkish fort that fell into Russian hands in 1789 it has rapidly become the intellectual and commercial capital of what is called New Russia It is the principal export town for the extensive grain growing districts of South Russia, the See of an Archbishop of the Greek Orthodox Church the center of a fine university and the headquarters of the Seventh Army Corps

The port lies on the shore of the Black Sea about midway between the estuaries of the Dniester and the Dnieper, 967 miles from Moscow and 351 from Kieff The city is built facing the sea, on low cliffs seamed with deep ravines and hollowed out by galleries in the soft rock, in which thousands of the poorest inhabitants live But above this are fine broad tree lined streets and squares bordered with handsome public buildings and mansions in the Italian style, and good shops Besides the cathedral, there are dozens of other churches, a fine opera house, and the Palais Royal, which, with its gardens and park, is a favorite place of resort A magnificent flight of granite steps leads from the Richelieu monument to the harbors, and the shore is lined with granaries, some of which look like palaces.

The bay of Odessa, which has an area of fourteen square miles, was a dangerous anchorage, on account of its exposure to easterly winds, until the harbors within it, six in number, protected by moles and breakwaters were constructed Besides these, there are the harbor of the Russian Company for Navigation and Commerce, and the petroleum harbor These harbors are frozen for a few days only in winter, but navigation is rarely interrupted for more than sixteen days at the most

The population has steadily increased from 8,150 in 1796 to about 480,000 at the present day The total exports were valued some time ago at about $65,000,000 annually and the imports at about $40,000,000, about 8½ per cent of all the imports into Russia Grain and particularly wheat is the chief article of export Petroleum is also an important export at the present time The principal imports are raw cotton iron agricultural machinery coal chemicals jute copra and lead Well over 1,200 vessels of some 1,750,000 tonnage enter the port every year and of these about 700 with a tonnage of 1,250,000 are British —*The Daily Telegraph*

Translucent Glass Bricks

At a recent meeting of the Illuminating Engineers Society one of the speakers made a novel but eminently practical suggestion in regard to the interior lighting of buildings His remarks were as follows

Not long since a resident owner called my attention to the fact that the front rooms of his home were in day time the darkest ones in the house notwithstanding the fact that these rooms were the most used and the most important The darkness was caused there—and in fact will be caused in any average residence by the shielding effect of a large porch and overhanging eaves This is a very common condition and it seems peculiar to me that use has not been made of prism plate glass, or ribbed sheets in the form of skylights set in the veranda roof to direct the daylight against the face of the building and into the windows Glass with a smooth upper side and with prisms on its lower face parallel to the building would direct considerably more light into these front rooms than is found at present Going a little further it seems reasonable to me that use could be made of translucent glass brick or glass blocks in the actual construction of a building Such blocks could readily be made of a glass of pleasing color tints, impervious to weather and it is conceivable how many beautiful effects could be worked into spaces between pilasters, around domes, friezes, etc Many architects do not want to have the exterior of a building made characterless by the use of many windows. Glass brick, tinted the color of stone, would offer a solution of such a problem."

Preventing Soil Erosion

SOIL erosion is doing immense damage constantly and few people know how to apply preventive measures In the annual report of the Bureau of Soils of the Department of Agriculture a simple method of handling one class of erosions is described This is the case where the soil is being washed away in gullies and the remedy is to build a dam across the incipient gully through which a sewer pipe is passed connecting with an upright pipe situated at the upper side of the dam The hollow formed by the dam will fill with water in flood conditions until the top of the upright pipe is reached when the excess of water runs off quietly into the next field or into another impounding space below The cutting current of the draining water is stopped and the sediment carried by it settles above the dam thus tending to repair the damage previously done A suitable tile drain located under the dam will dispose of the water impounded below the opening of the upright pipe

A Valuable Sub-Tropical Hay Grass

AT the third International Congress of Tropical Agriculture attention was called to a valuable species of grass that has been introduced into South Africa with remarkable success This is known as Teff (*Eragrostis abassinica*) and is an annual hay grass, particularly suitable as a summer catch-crop and a smother-crop for weeds, owing to its rapid growth when weather conditions are at all favorable It gives a heavy yield of hay of fine quality and high nutritive value more nearly resembling English meadow hay than any other hay grass grown in South Africa If sown with the early spring rains it has been possible to cut three crops of hay in the season, giving 2½ to 3 tons per acre, and to obtain autumn grazing from the aftermath The introduction of Teff grass into South Africa has raised many small farmers struggling for a living to positions of comparative comfort and independence They are unanimously agreed that this introduction alone has repaid over and over again the whole cost of the Division of Botany of the Department of Agriculture from its inception to date

Native pearl fishers at work on a bank

An inspector about to descend in a diving dress

The Pearl Fisheries of Ceylon

How the Pearl Bearing Oysters are Gathered by Naked Divers

By R I Geare

The finding of large and valuable pearls has been a matter of deep interest to mankind for centuries The Ceylonese fisheries which had been operated at intervals since long before the Christian era are probably the most ancient of these fisheries The most perfect pearl ever discovered in that region was bought in 1633 by the Shah of Persia for about $51 000 from an Arab who brought it from Catifa a fishery opposite Bhareen in the Persian Gulf Another magnificent pearl—a black specimen—was sold to a New York firm not many years ago for about $25 000

The true pearl oyster known scientifically as *Meleagrina margaritifera* and belonging to the family Aviculidae differs from the edible oyster in having a small 'foot and anterior adductor muscle a well-developed byssus gland which secretes a bunch of fibers by which the animal is attached to rock or stone and a thick 'mother of pearl layer to the shell

The Ceylon fisheries are operated on banks covering an extensive area off the north coast of the island Tradition has it that King Solomon obtained some of his wonderful pearls from the Ceylon banks and even the pearls which Cleopatra dissolved and drank are credited with a Ceylonese origin

The banks most famous in past times lie close to the shore in the Gulf of Mannar near a place called Marichchukkaddi

At one time when Ceylon was under the Tamil power the pearl fisheries were conducted frequently and successfully They were watched over by a Tamil princess who was carried to the end of the Karaittiva Point, and there enthroned until the fishery was over to prevent robbery on the part of the divers

One of the earliest mentions of pearl fisheries in Ceylon occurs in the Rajavali chronicle (306 B C) where they are spoken of as being located near Colombo but they were unfortunately destroyed by an inundation from the sea

During the Portuguese control of the island of Ceylon there is no record of any pearl fishing but during the 140 years it was occupied by the Dutch there were at least four important fisheries between 1732 and 1749 in the course of which probably not less than a million dollars worth of pearls were secured

During the British occupancy of Ceylon which still exists the pearl banks have been under the inspectorship of the Master Attendant of the port of Colombo while the government agent of the Northern Province acts as Official Superintendent

The oyster beds are formed by an amalgam of coarse granite sand and old oyster shells cemented together with coral lime Here there is but little movement of the sand so that the oysters remain easily accessible but away from the beds the sand which is loose is formed into huge waves which have the effect of covering up and destroying the oysters immediately

The life of a Ceylon pearl oyster is not more than eight years and from about its third year it seems to be most productive both in the number and size of pearls As a matter of fact very few 8 year oysters contain valuable pearls but when a bed of oysters is fished just as they are dying off with old age the pearls obtained are liable to be many and large

True pearls which are in fact, the result of a disease sometimes brought about by the introduction into the shell of some foreign body such as a grain of sand an undeveloped egg a parasite, etc are formed in the tissue of the oyster and when they reach such a size as to cause great discomfort to the oyster the latter either dies or forces the pearl toward the opening between the valves where it is retained by an absolutely transparent substance or skin and here it increases in growth.

Owing to the monsoons pearl fishing can be carried on only in March and April During the preceding fall or early winter (generally in November) the inspector causes some 20 000 oysters to be lifted and if the average is satisfactory the fishery is ordered When the proper time arrives the boats each containing divers who work five at a time are rowed or sailed to the banks Each pair of divers has an attendant known as a manduck The boat also contains a tindal or representative of the owner of the boat and a peon who represents the interests of the government.

The divers are allowed for payment one third of the oysters taken while the government auctions off the remainder on the beach the same evening they are caught. The oysters are then placed by the purchasers in kottus or inclosures and are allowed to rot for eight or ten days in some receptacle—often a wooden canoe—which is covered over to shade the oysters from the sun but permits flies to obtain free access as they assist in the process of rotting Later the whole mass is washed with clean water the shells stones and byssus (or green string like substance by which the oyster attaches itself to the rock) are picked out and the residue placed on long stripe of black calico to dry During the drying process the whole mass is picked over and over again and carefully scrutinized for the smallest pearls

In classifying the pearls a series of brass cullenders or baskets is used They are about the size of an ash tray and are provided with holes which are of even size in each basket. The one with the largest sized holes has twenty of them while others have as many as several hundred holes each By this method of sifting the larger pearls are readily preserved but the tiny seed pearls are often accidentally left in large numbers near the oyster washing place and for a long time afterward men and women search the sands for these minute treasures

Seed pearls it may be explained are chiefly used by Indian princes being pounded into powder to form chunam for betel-chewing and they are also extensively employed in embroideries and cluster necklaces.

The actual operation of diving for pearl oysters is in this wise When the divers are ready they climb over the side of the vessel place one foot on a large stone which is held clear of the boat by two poles fastened

Pearl oysters in a Kottu, or rotting inclosure

Pearl fishers landing their catch.

at right angles over the boat's side, and by a third pole which lies parallel to the length of the vessel and is lashed to each end of the other two.

Grasping the rope which is attached to this stone and hitching over his arm the rope attached to the basket in which the diver places his catch, he takes a deep breath, closing his nostrils with his free hand, and slightly raising himself—to add impetus to his descent—gives the signal to the "manduck" to release the rope to which the stone is fastened. On reaching the bottom the diver lets go of the stone, which is then hauled up, so as to be ready for the next descent, and, swimming on the bottom, grasps all the oysters within his reach. When his breath is nearly exhausted, the diver signals to be pulled up with his basket and rises partly by his own initiative. Occasionally the divers are severely stung by jellyfishes, and sometimes they stay down too long and, actuated by avarice or overestimating their own strength, are brought up dead. When collecting the oysters they seem to float on the bottom of the sea, with backs arched and heels above their heads, while their long hair waves in a graceful manner and is upheld by the action of the water. A Tamil diver remains below from 50 to 60 seconds, but an Arab can stay down from 80 to 90 seconds.

Diving bells were imported into Ceylon by Sir Edwards Barnes in 1825, but they nor Europeans in a diving dress can compete with the naked diver.

The catch of one boat for a successful week's fishing should total about 180,000 oysters.

X-Rays and Crystalline Structure*

Discoveries That Assist in the Understanding of Theories of X-Rays and Light

By Prof. William H. Bragg

Two years have gone by since Dr. Laue made his surprising discovery of the interference effects accompanying the passage of X-rays through crystals. The pioneer experiment has opened the way for many others, and a very large amount of work, theoretical and practical, has now been done. As the preliminary exploration of the new country has proceeded, our first estimate of its resources has grown continuously; we have learned many things which help us to a better understanding of phenomena already familiar, and we have seen avenues of inquiry open out before us which as yet there has been little time to follow. The work is full of opportunities for exact quantitative measurements, where precision is sure to bring its due reward. There is enough work in sight to absorb the energies of many experimenters, and there is sure to be far more than we can see. When we consider the wideness of the new field, the quality and quantity of the work to be done in it, and the importance of the issues, we are scarcely guilty of over-statement if we say that Laue's experiment has led to the development of a new science.

The experiment itself, to put it very briefly, constitutes a proof that X-rays consist of extremely short ether waves. In order to appreciate the value of this demonstration, we must bear in mind the present conditions of our knowledge of the laws of radiation in general. Let us consider very shortly how the whole matter stood when the new work was begun.

When X-rays were first discovered eighteen years ago it was soon pointed out that they might consist of electro-magnetic disturbance of the ether analogous to those supposed to constitute light. It was true that the new rays seemed to be incapable of reflection, refraction, diffraction and interference, which were familiar optical phenomena. But it was pointed out by Schuster[1] that these defects could be explained as natural consequences of an extremely small wave-length. The positive evidence consisted mainly in the knowledge that the impact of the electrons on the anti-cathode of the X-ray bulb ought to be the occasion of electro-magnetic waves of some sort, and in the discovery by Barkla that the X-rays could be polarized, which last is a property also of light.

As experimental evidence accumulated, a number of results were found which the electro-magnetic theory was unable to explain, at least in a direct and simple manner. They were mainly concerned with the transference of energy from place to place. In some way or other the swiftly moving electron of the X-ray bulb transfers its energy to the X-ray, and the X-ray in its turn communicates approximately the same quantity of energy to the electron which originates from matter lying in the track of the X-ray, and which is apparently the direct cause of all X-ray effects. Experiment seemed to indicate that X-ray energy traveled as a stream of separate entities or quanta, the energy of the quantum differing according to the quality of the X-ray. It looked at one time as if it might be the simplest plan to deny the identity in nature of X-rays and light, to describe the former as a corpuscular radiation and the latter as a wave motion. Otherwise, it seemed that the electro-magnetic hypothesis would be torn to pieces in the effort to hold all the facts together.

But it appeared on a close examination of light phenomena also, though in much less obvious fashion, that the very same effects occurred which in the case of X-rays were so difficult to explain from an orthodox point of view. In the end it became less difficult to deny the completeness of the orthodox theory than the identity in nature of light and X-rays. Modern work on the distribution of energy in the spectrum, and the dependence of specific heat upon temperature, has also led independently to the same point of view. It has been urged with great force by Planck, Einstein, and others that radiated energy is actually transferred in definite units or quanta, and not continuously; as if we had to conceive of atoms of energy as well as of atoms of matter. Let it be admitted at once that the quantum theory and the orthodox theory appear to stand in irreconcilable opposition. Each by itself correlates great series of facts; but they do not correlate the same series. In some way or other the greater theory must be found, of which each is a partial expression.

The new discovery does not solve our difficulty at once, but it does two very important things. In the first place, it shows that the X-rays and light are identical in nature; in fact, it removes every difference except in respect to wave-length. The question as to the exact place where the difficulty lies is decided for us, we are set the task of discovering how a continuous wave motion, in a continuous medium, can be reconciled with discontinuous transferences of radiation energy. Some solution there must be to this problem. The second important thing is that the new methods will surely help us on the way to find that solution. We can now examine the X-rays as critically as we have been able to study light, by means of the spectrometer. The wave-length of the X-ray has emerged as a measurable quantity. The complete range of electro-magnetic radiations now lies before us. At one end are the long waves of wireless telegraphy, in the middle are first the waves of the infra-red detected by their heating effects, then the light waves, and then the short waves of the ultra-violet. At the other end are the extremely short waves that belong to X-radiation. In the comparative study of the properties of radiation over this very wide range we must surely find the answer to the greatest question of modern physics.

So much for the general question. Let us now consider the procedure of the new investigations, and afterwards one or two applications to special lines of inquiry.

The experiment due to Laue and his collaborators Friedrich and Knipping has already been described in this lecture room and is now well known. A fine pencil of X-rays passes through a thin crystal slip and impresses itself on a photographic plate. Round the central spot are found a large number of other spots, arranged in a symmetrical fashion, their arrangement clearly depending on the crystal structure. Laue had anticipated some such effect as the result of diffraction by the atoms of the crystal. His mathematical analysis is too complicated to be described now, and indeed it is not in any circumstances easy to handle. It will be better to pass on at once to a very simple method of apprehending the effect which was put forward soon after the publication of Laue's first results. I must run the risk of seeming to be partial if I point out the importance of this advance, which was made by my son W. Lawrence Bragg. All the recent investigations of X-ray spectra and the examination of crystal structure and of molecular motions which have been carried out since then have been rendered possible by the easy grasp of the subject which resulted from the simpler conception.

Let us imagine that a succession of waves constituting X-radiation falls upon a plane containing atoms, and that each atom is the cause of a secondary wavelet. In a well known manner, the secondary wavelets link themselves together and form a reflected wave. Just so a sound wave may be reflected by a row of palings, and very short sound waves by the fibers of a sheet of muslin.

Suppose a second plane of atoms to lie behind the first and to be parallel to it. The primary wave, weakened somewhat by passing through the first plane, is again partially reflected by the second. When the two reflected pencils join it will be of great importance whether they fit crest to crest and hollow to hollow, or whether they tend to destroy each other's effect. If more reflecting planes are supposed, the importance of a good fit becomes greater and greater. If the number is very large, then, as happens in many parallel cases in optics, the reflected waves practically annul each other unless the fit is perfect.

It is easily seen that the question of fit depends on how much distance a wave reflected at one plane loses in comparison with the wave which was reflected at the preceding plane: the fit will be perfect if the loss amounts to one, two, three, or more wave-lengths exactly. In its turn the distance lost depends on the spacing of the planes, that is to say, the distance from plane to plane, on the wave-length, and on the angle at which the rays meet the set of planes.

The question is formally not a new one. Many years ago Lord Rayleigh discussed it in this room, illustrating his point by aid of a set of muslin sheets stretched on parallel frames. The short sound waves of a high pitched bird call were reflected from the set of frames and affected a sensitive flame; and he showed how the spacing of the planes must be carefully adjusted to the proper value in relation to the length of wave and the angle of incidence. Rayleigh used the illustration to explain the beautiful color of chlorate of potash crystals. He ascribed them to the reflection of light by a series of parallel and regularly spaced twinning planes within the crystal, the distance between successive planes bearing, roughly, the same proportion to the length of the reflected wave of light at the distance between the muslin sheets to the length of the wave of sound.

Our present phenomenon is exactly the same thing on a minute scale; thousands of times smaller than in the case of light; and many millions of times smaller than in the case of sound.

By the kindness of Prof. R. W. Wood I am able to show you some fine examples of the chlorate of potash crystals. If white light is allowed to fall upon one of them, the whole of it is not reflected. Only that part is reflected which has a definite wave-length or something very near to it, and the reflected ray is therefore highly colored. The wave length is defined by the relation already referred to. If the angle of incidence is altered, the wave length which can be reflected is altered, and so the color changes.

It is not difficult to see the analogy between these cases and the reflection of X-rays by a crystal. Suppose, for example, that a pencil of homogeneous X-rays meets the cube face of such a crystal as rocksalt. The atoms of the crystal can be taken to be arranged in planes parallel to that face, and regularly spaced. If the rays meet the face at the proper angle, and only at the proper angle, there is a reflected pencil. It is to be remembered that the reflection is caused by the joint action of a series of planes, which, in this case, are parallel to the face, it is not a reflection by the face itself. The face need not even be cut truly; it may be unpolished or deliberately roughened. The reflection takes place in the body of the crystal, and the condition of the surface is of little account.

The allotment of the atoms to a series of planes parallel to the surface is not, of course, the only one possible. For example, in the case of a cubic crystal, parallel planes containing all the atoms of the crystal may also be drawn perpendicular to a face diagonal of the cube, or to a cube diagonal, or in many other ways. We may cut the crystal so as to show a face parallel to any series, and then place the crystal so that reflection occurs, but the angle of incidence will be different in each case since the spacings are different. It is not necessary to cut the crystal except for convenience. If wave-length, spacing, and angle between ray and plane are rightly adjusted to each other, reflection will take place in the crystal independently of any surface arrangement.

This is the "reflection" method of explaining the Laue photograph. W. L. Bragg showed in the first place that it was legitimate, and in the second, that it was able to explain in the position of all the spots which Laue found upon his photographs. The different spots are

* Read before the Royal Institution of Great Britain, June 5th, 1914.

[1] Nature, January 23rd, 1896.

reflections in different series of planes which may be drawn to contain the atoms of the crystal. The simpler conception led at once to a simpler procedure. It led to the construction of the X ray spectrometer which resembles an ordinary spectrometer in general form except that the grating of prism is replaced by a crystal and the telescope by an ionisation chamber and an electroscope. In use a fine pencil of X rays is directed upon the crystal, which is steadily turned until a reflection leaps out and the angle of reflection is then measured. If we use different crystals or different faces of the same crystal but keep the rays the same we can compare the geometrical spacings of the various sets of planes. If we use the same crystals always but vary the source of X rays we can analyse the latter measuring the relative wave lengths of the various constituents of the radiation.

We have thus acquired a double power. (1) We can compare the intervals of spacing of the atoms of a crystal or of different crystals along various directions within the crystal. In this way we can arrive at the structure of the crystal. (2) We can analyse the radiation of an X ray bulb. In fact we are in the same position as we should have been in respect to light if our only means of analysing light had been the use of colored glasses and we had then been presented with a spectrometer or some other means of measuring wave-length exactly.

We now come to a critical point. If we knew the exact spacings of the planes of some one crystal we could now by comparison find the spacing of all other crystals and measure the wave-length of all X radiations or if we knew the exact value of some one wave length we could find by comparison the values of all other wave-lengths and determine the spacings of all crystals. But as yet we have no absolute value either of wave length or of spacings.

The difficulty appears to have been overcome by W. L. Bragg's comparison of the reflecting effect in the case of rocksalt or sodium chloride and sylvine or potassium chloride. These two crystals are known to be isomorphous: they must possess similar arrangements of atoms. Yet they display a striking difference both in the Laue photograph and on the spectrometer. The reflections from the various series of planes of the latter crystal show spacings consonant with an arrangement in the simplest cubical array of which the smallest element is a cube at each corner of which is placed the same group, a single atom or molecule or group of atoms or molecules. In the case of rocksalt the indications are that the crystal possesses a structure intermediate between the very simple arrangement just described and one in which the smallest element is a cube having a similar group of atoms or molecules at every corner and at the middle point of each face. The arrangement is called by crystallographers the face centered cube. The substitution of the sodium for the potassium atom must transform one arrangement into the other. This can be done in the following way if we accept various indications that atoms of equal weight are to be treated as equivalent. Imagine an elementary cube of the crystal pattern to have an atom of chlorine at every corner and in the middle of each face and an atom of sodium or potassium as the case may be at the middle point of each edge and at the center of the cube. We have now an arrangement which fits the facts exactly. The weights of the potassium and chlorine atoms are so nearly the same as to be practically equivalent and when they are considered to be so the arrangement becomes the simple cube of sylvine. But when the lighter sodium replaces the potassium as in rocksalt the arrangement is on its way to be that of the face centered cube and would actually become so were the weight of the sodium atoms negligible in comparison with those of chlorine. Of course the same result would follow were two or three or any number of atoms of each sort to take the place of the single atom provided the same increase were made in the number of atoms of both sorts. We might even imagine two sorts of groups of chlorine and metal atoms, one containing a preponderance of the former the other of the latter but so that two groups one of each kind contain between them the same proportion of chlorine and metal as the crystal does. We must merely have two groups which differ in weight in the case of rocksalt and are approximately equal in the case of sylvine. But it was best to take the simplest supposition at the outset and now the evidence that the right arrangement has been chosen is growing as fresh crystals are measured. For it turns out that in all crystals so far investigated the number of atoms at each point must always be the same. Why then should it be more than one? Or in other words if atoms are always found in groups of a certain number ought not that group to be called the atom?

As soon as the structure of a crystal has been found we can at once find by simple arithmetic the scale on which it is built. For we know from other sources the weight of individual atoms, and we know the total weight of the atoms in a cubic centimeter of the crystal. In this way we find that the nearest distance between two atoms in rocksalt is 2.81×10^{-8} centimeters which distance is also the spacing of the planes parallel to a cube face. From a knowledge of this quantity the length of any X ray wave can be calculated at once as soon as the angle of its reflection by the cube face has been measured. In other words the spectrometer has now become a means of measuring the length of waves of any X radiation and the actual spacings of the atoms of any crystal.

From this point the work branches out in several directions. It will not be possible to give more than one or two illustrations of the progress along each branch.

Let us first take up the most interesting and important question of the characteristic X rays. It is known that every substance when bombarded by electrons of sufficiently high velocity emits X rays of a quality characteristic of the substance. The interest of this comparison lies in the fact that it displays the most fundamental properties of the atom. The rays which each atom emits are characteristic of its very innermost structure. The physical conditions of the atoms of a substance and their chemical associations are largely matters of the exterior but the X rays come from the interior of the atoms and give us information of an intimate kind. What we find is marked by all the simplicity we should expect to be associated with something so fundamental.

All the substances of atomic weight between about 30 and 120 give two strongly defined lines, that is to say there are found among the general heterogeneous radiation two intense almost homogeneous sets of waves. For instance rhodium gives two pencils of wave lengths approximately equal to 0.61×10^{-8} centimeters and 0.54×10^{-8} centimeters respectively. More exactly the former of these is a close doublet having wave-lengths 0.619×10^{-8} and 0.614×10^{-8}. The wave lengths of palladium are nearly 0.58×10^{-8} and 0.51×10^{-8}; nickel 1.66×10^{-8} and 1.50×10^{-8}. Lately Moseley has made a comparative study of the spectra of the great majority of the known elements and has shown that the two line spectrum is characteristic of all the substances whose atomic weights range from that of aluminium 27 to that of silver 108. These X rays constitute there is no doubt whatever the characteristic rays which Barkla long ago showed to be emitted by this series of substances.

Now comes a very interesting point. When Moseley sets the increasing atomic weights against the corresponding decreasing wave lengths the changes do not run exactly parallel with each other. But if the wave lengths are compared with a series of natural numbers everything runs smoothly. In fact it is obvious that the steady decrease in the wave length as we pass from atom to atom of the series in the periodic table implies that some fundamental element of atomic structure is altering by equal steps. There is excellent reason to believe that the change consists in successive additions of the unit electric charge to the nucleus of the atom. We are led to think of the magnitude of the nucleus of any element as being simply proportional to the number indicating the place of the element in the periodic table, hydrogen having a nuclear charge of one unit, helium two and so on. The atomic weights of the successive elements do not increase in an orderly way: they mount by steps of about two but not very regularly and sometimes they seem absolutely to get into the wrong order. For example nickel has an atomic weight of 58.7 whereas certain chemical properties and still more its behavior in experiments on radio activity indicate that it should lie between cobalt (59) and copper (63.6). But the wave lengths, which are now our means of comparison, diminish with absolute steadiness in the order cobalt, nickel, copper. Plainly the atomic number is a more fundamental index of quality than the atomic weight.

It is very interesting to find in the series arranged in this way four and only four gaps which remain to be filled by elements yet undiscovered.

Let us now glance at another and most important side of the recent work, the determination of crystalline structure. We have already referred to the case of the rocksalt series but we may look at it a little more closely in order to show the procedure of crystal analysis.

The reflection of a pencil of homogeneous rays by a set of crystalline planes occurs as already said at a series of angles regularly increasing, giving as we say spectra of the first, second, third orders and so on. When the planes are all exactly alike and equally spaced the intensities of the spectra decrease rapidly as we proceed to higher orders, according to a law not yet fully explained. This is, for example, the case with the three most important sets of planes of sylvine, those perpendicular to the cube edge, the face diagonal and the cube diagonal respectively. An examination of the arrangement of the atoms in the simple cubical array of sylvine shows that for all these sets the planes are evenly spaced and similar to each other. It is to be remembered that the potassium atom and the chlorine atom are so nearly equal in weight that they may be considered effectively equal. In the case of rocksalt the same may be said of the first two sets of planes, but not of the third. The planes perpendicular to the cube diagonal are all equally spaced but they are not all of equal effect. They contain alternately chlorine atoms (atomic weight 35.5) only and sodium atoms (atomic weight 23) only. *The effect of this irregularity on the* intensities of the spectra of different orders is to enhance the second, fourth and so on in comparison with the first, third, and fifth. The analogous effect in the case of the light is given by a grating in which the lines are alternately light and heavy. A grating specially ruled for us at the National Physical Laboratory shows this effect very well. This difference between rocksalt and sylvine and its explanation in this way constituted an important link in W. Lawrence Bragg's argument as to their structure.

When therefore we are observing the reflections in the different faces of a crystal in order to obtain data for the determination of its structure we have more than the values of the angles of reflection to help us: we have also variations of the relative intensities of the spectra. In the case just described we have an example of the effect produced by want of similarity between the planes, which are however uniformly spaced.

In the diamond on the other hand we have an example of an effect due to a peculiar arrangement of planes which are otherwise similar. The diamond crystallises in the form of a tetrahedron. When any of the four faces of such a figure is used to reflect X rays it is found that the second order spectrum is missing. The analogous optical effect can be obtained by ruling a grating so that as compared with a regular grating of the usual kind the first and second, fifth and sixth, ninth and tenth alone are drawn. To put it another way two are drawn, two left out, two drawn, two left out and so on. The National Physical Laboratory has ruled a special grating of this kind also for us and the effect is obvious. The corresponding inference in the case of the diamond is that the planes parallel to any tetrahedral face are spaced in the same way as the lines of the grating. Every plane is three times as far from its neighbor on one side as from its neighbor on the other. There is only one way to arrange the carbon atoms of the crystal so that this may be true. Every atom is at the center of a regular tetrahedron composed of its four nearest neighbors, an arrangement best realized by the aid of a model. It is a beautifully simple and uniform arrangement and it is no matter of surprise that the symmetry of the diamond is of so high an order. Perhaps we may see also in the perfect symmetry and consequent effectiveness of the forces which hold each atom to its place an explanation of the hardness of the crystal.

Here then we have an example of the way in which peculiarities of spacing can be detected. There are other crystals in which want of uniformity both in the spacings and in the effective value of the planes combine to give cases still more complicated. Of these are iron pyrites, calcite, quartz and many others. It would take too long to explain in detail the method by which the structures of a large number of crystals have already been determined. Yet the work done already is only a fragment of the whole and it will take no doubt many years even though our methods improve as we go on before the structures of the most complicated crystals are satisfactorily determined.

On this side then we see the beginning of a new crystallography which though it draws freely on the knowledge of the old yet builds on a firmer foundation since it concerns itself with the actual arrangement of the atoms rather than the outward form of the crystal itself. We can compare with the internal arrangements we have now discovered the external forms which crystals assume in growth and the modes in which they tend to come apart under the action of solvents and other agents. By showing how atoms arrange and disarrange themselves under innumerable variations of circumstances we must gain knowledge of the nature and play of the forces that bind the atoms together.

There is yet a third direction in which inquiry may be made though as yet we are only at the beginning of it. In the section just considered we have thought of the atoms as at rest. But they are actually in motion and the position of an atom to which we have referred so frequently must be an average position about which it is in constant movement. Since the atoms are never exactly in their places, the precision of the joint action on which the reflection effect depends suffers materially. The effect is greater the higher the order of the spectrum. When the crystal under examination is contained within a suitable electric furnace and the atoms vibrate more violently through the rise of temperature,

the intensities of all orders diminish, but those of higher order much more than those of lower The effect was foreseen by the Dutch physicist Debije and the amount of it was actually calculated by him on certain assumptions I have found experimental results in general accord with this formula In passing it may be mentioned that as the crystal expands with rise of temperature the spacing between the planes increases and the angles of reflection diminish an effect readily observed in practice

This part of the work gives information respecting the movements of the atoms from their places the preceding respecting their average positions It is sure like the other to be of much assistance in the inquiry as to atomic and molecular forces and as to the degree to which thermal energy is locked up in the atomic motions

This brief sketch of the progress of the new science in certain directions is all that is possible in the short time of a single lecture but it may serve to give some idea of its fascination and possibilities

The Geology of the Yellowstone National Park

A Striking Topographical Structure and a Complete Geological Problem

By Carl Hawes Butman

In the year 1872 Congress set aside a tract of land in the the northwest corner of Wyoming for the benefit of mankind and the preservation of the natural wonders of the country This became known as the Yellowstone National Park and was the first tract thus set aside for this purpose It includes some 3 340 square miles but in relation to the whole of Wyoming it appears on the map as a misplaced postage stamp which like many stamps overlaps the letter by extending a little way into both Montana and Idaho Following the precedent thus established 40 years ago Congress has since established eleven smaller parks in various places where the public might find recreation and where the wonders of nature therein might be preserved from desecration

From the point of view of the geologist Yellowstone Park is in a way unique Its central plateau with the adjacent mountains presents a sharply defined region contrasting with the remainder of the northern Rocky Mountains a striking piece of topographical structure and a complete geological problem The central portion consists of a broad elevated irregular plateau of volcanic origin some 40 miles square extending between 7 000 and 8 500 feet above sea level and surrounded on the north northwest south east and northeast by mountain ranges the peaks and highest points of which extend upward like a gigantic wall for 2 000 to 4 000 feet more

Just south of the park the Tetons the highest and grandest peaks in the northern Rocky Mountains stand out prominently but only the outlying spurs come within the limits of the park proper These mountains are composed mostly of coarse crystalline gneisses and shists probably of Archean age abutted on the northern spurs by upturned Paleozoic strata

On the eastern edge of the park the Absaroka Range stretches from the north to the south where it connects with the northern end of the Wind River Range For more than 80 miles this range presents a bold unbroken barrier along the eastern side of the park its highest peaks towering 10 000 or 11 000 feet aloft

At the northeastern corner of the park an irregular mass of mountains joins the Absarokas with the Snowy Range which forms the northern boundary of the reservation with its rough snow-covered elevations The rocks of the southern slopes of the Snowy Range which extend into the park are composed mainly of granite gneiss and shist, while their sedimentary beds belong to the pre-Cambrian series

Enclosing the park on the northwestern corner lies the Gallatin Range separated from the Snowy Range on the east by the valley of the Yellowstone River It is a beautiful mountain range presenting diversified forms as well as varied geological problems Its crowning glory Electric Peak 11 100 feet in height and incidentally the tallest peak in this region gets its name from the magnetic disturbances discovered by the first explorers to carry surveying instruments up its slopes An important part of the Gallatin Range is formed of Archean gneisses covered with a series of limestone sandstone and shale beds both of the Paleozoic and Mesozoic eras, representing Cambrian Silurian Devonian Carboniferous, Triassic Jurassic and Cretaceous periods Large masses of intrusive rocks closely allied with the sedimentary beds have taken an important part in creating the present structural features of this range They are of the andesitic type and cover a broad range of mineral composition including pyroxene, hornblende and hornblende-mica

The general region of the park was at one time subjected to severe dynamic action which affected all the ranges at about the same time, and probably occurred during the latter part of the Cretaceous period although the work of mountain building seems to have continued into the Middle Tertiary period During the latter period the site of the park was torn up by volcanic action which continued to a lesser extent through the Pliocene and into the Quaternary periods All such action has long since ceased, but the volcanic rocks remain offering much interesting information They comprise three groups which succeeded each other andesites with basalts, rhyolites, and basalts Probably the andesitic eruptions continued for the greatest period of time since there are evidences of plant life buried under 2 000 feet of volcanic material

In Tertiary times there is supposed to have existed a large volcano named the Sherman and of which Mount Washburn is a more recent crater the bursting forth of which caused the destruction of the original crater of the older volcano Recent eruptions and erosions have so destroyed the early volcanic flows that it is difficult to identify the ancient andesitic lava which was afterwards submerged by immense quantities of rhyolite to a thickness of nearly 8 500 feet In fact nothing else remains to be seen but rhyolitic rock except the mineral spring deposits and the remains of the early crater rim on Mount Washburn Another source of the rhyolite flows is supposed to have been Mount Sheridan in the southern part of the reservation which towers to a height of 10 385 feet and offers a remarkable view of the volcanic region stretching across the park from east to west The deep gorges of the Yellowstone Gibbon and Madison Rivers have not worn through this tremendous thickness of rock and only in the Grand Canyon of the Yellowstone are the ancient andesitic breccias exposed beneath the rhyolites while nowhere are the sedimentary beds revealed The central plateau includes the finest examples of structural forms crystallization and mode of origin of acidic lavas varying from a nearly holocrystalline rock to pure volcanic glass that can be found in the world

Following the rhyolite eruption there came a period of faulting and displacement succeeded by eruptions of basalt which however deposited but a thin layer over the rhyolite and did practically nothing to change the physical aspect of the country The glacial action which soon occurred nevertheless carved out the early drainage channels cut gorges into the rhyolite lava and shaped the two volcanoes into their present form Traces of the ancient glaciers are to be found nearly everywhere especially in the several mountain ranges while in the Tetons there exist to-day glaciers characteristic of the ancient grand system which extended over the entire plateau Erosion continued the work of the glaciers in remodeling the park surface and this action has carved since that time the deep gorges of the Madison Gibbon and Yellowstone rivers veritable canyons cut to a depth of nearly 1 500 feet and several miles in length

Much evidence of the great glacial action is still at hand the valley of the lower Yellowstone River is strewn with rocks brought by the glacier from both the east and west borders of the park One example of the tremendous force of the ice floes of the early times is a great granite bowlder (about 20 feet in diameter) brought down and deposited on the brink of the Grand Canyon It is completely isolated from its fellows and quite 30 miles from where it must have been transported The glacial action took place since the travertine deposits of the hot springs were formed This is shown especially at Terrace Mountain near the Mammoth Hot Springs where the travertine covering the rhyolite plateau is strewn with glacial bowlders brought from the Gallatin Range some 15 miles away indicating that the travertine is older than the glacier

Probably the most interesting feature of the park today is the series of hot-water fountains or geysers which occur in three principle localities Norris Lower and Upper Basins and include 16 23 and 45 geysers respectively The first group is located on the Gibbon Canyon Road about 20 miles south of the Mammoth Hot Springs The second about 20 miles farther to the south near the Fountain Hotel, is 7 240 feet in altitude and largest of the three basins but its individual geysers are scattered over a considerable area and not as available for inspection The Upper Basin offers the most interesting and largest fountains The Giant Geyser which plays every seven or twelve days for about an hour is the largest of the park geysers since the Excelsior of the Lower Basin ceased to play in 1888 It shoots a stream of hot-water and steam to a height of between 200 and 250 feet Another famous geyser of this basin is Old Faithful situated in the southernmost part at an altitude of 7,300 feet This geyser has the reputation of maintaining a regular schedule as it plays every 60 or 75 minutes for a period of about 4 minutes shooting its water column aloft for 125 or more feet and has kept to its schedule since its discovery in 1870 One geologist has estimated its flow at 3 000 barrels per eruption

Although the park's volcanoes are extinct the steam fountains which still exist are dependent upon the heated rocks and gases far below the surface which raise the temperature of the percolating surface waters under great pressure and cause them to return to the surface with tremendous energy often bursting out in fountains of hot-water and steam Other theories as to the origin of geysers have been advanced that they are caused by chemical action or burning coal but of late scientists have shown that geysers and hot-water springs are only found in regions where volcanic rock abounds and the general conclusion points out that the steam source is the still hot lava deep within the earth

The ascending steam and hot-water have caused great geological changes in the surface rocks through which they have passed as may be seen at many points in the park especially in the Grand Canyon of the Yellowstone where the walls are colored for three miles below the Lower Falls by this action Fully 1 000 feet of the wall from the brink to the water below is decomposed rhyolite varying in hue through orange red purple and yellow Here too the ancient steam vents may be descried while at the bottom of the canyon there are steam vents hot springs and fumaroles which are still active

Besides enabling the scientist to study the old vents and the discoloration of the walls the Grand Canyon offers a fine example of erosion conducted on an immense scale within recent geological times and its course was obviously determined by the easily eroded decomposed rocks caused by the ascending steam and hot-water mentioned above The two falls of the Yellowstone offer another feature of interest to the student since they present a graphic example of the wearing effect of water upon the rocky walls and bed The Lower Falls are the larger being 308 feet in sheer drop

The Mammoth Hot Springs are located 4 miles south of the northern park entrance at Gardiner and here also is situated the hotel of that name together with the army post Southwest of the hotel is Terrace Mountain an outlying ridge of the rhyolite plateau which is covered with thick beds of travertine deposited by the hot water in the form of terraces from which the mountain derives its name The deposits of the hot springs at this place are far different from those upon the plateau Here they are nearly pure travertine with traces of silica analyses indicate about 97 per cent calcium carbonate while on the plateau the greater part of the deposits are of siliceous sinter called geyserite This variation is on account of the fact that the Mammoth Springs are formed by steam coming up from far below through the water of the Mesozoic strata the Cretaceous limestones furnishing the lime held in solution and deposited on the surface as travertine while the mineral constituents of the plateau waters are derived mainly from highly acidic lavas carrying only a small portion of lime

The terraces of the Mammoth Hot Springs present the appearance of banks of ice and snow with irregular basins of water in their glimmering stepped terraces Among the important ones are Minerva Cleopatra Hymen Pulpit Jupiter and Mound Terraces while the springs which flow into and over them are named Jupiter Diana Palette Naiad and others The coloring of the spring waters here is marvelous in its harmony and brilliant tints and is due to Algae which grow in hot water up to a temperature of about 185 deg Fahr Many of the springs present the appearance of boiling caldrons of water although this is not the case the bubbles being formed by escaping carbonic-acid gas

Yellowstone Park with its many geological formations its ancient volcanoes lava flows hot springs and geysers presents a wonderful natural laboratory for the geologist as well as the chemist Its formation dates back to that of the central table land of the continent and yet changes are still going on within its limits though not as actively as heretofore which make it an ever interesting problem for the scientist


Cone of the Giant Geyser as it appears when not playing


The Giant Geyser the largest geyser in the park.


The famous Old Faithful Geyser


Lo g up the Grand Canyon from Inspirat on Point


Th Punch Bowl located northw st of the Upper Geyser Bas n


Eagle Rest Rock near Gardiner the northern entrance

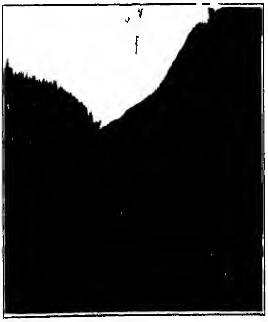

The Golden Gate Swan Lake B n


The r ad along h C n n a D v d


Washburn Ho Spr ngs n ra l from th Grand Canyon to Lower Falls Station


The Keppler Cascades, near Two Ocean Ponds


The Great Falls of the Yellowstone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THE GEOLOGY OF THE YELLOWSTONE NATIONAL PARK

Purification of Water by the Ultra-Violet Rays*

Principles Underlying the Most Recent System for Destroying Germ Life

By M. von Recklinghausen, Ph.D.

It is a matter of common knowledge nowadays that the ultra violet rays have a strong bactericidal power. Within the last few years this power of annihilating microbes by ultra violet rays has been applied for freeing water of germs and a new industry has sprung up which produces water purifiers that make use of this new principle to sterilize water for drinking and other purposes. As this system is being applied successfully to large water plants, it is of interest for the professional water engineer to be fully informed on the principles underlying this most recent system of water purification.

The treatment of water by artificial light sources for the purpose of destroying its germ life dates back to Downes and Blunt (1878). They found that the shorter the wave lengths of the light the better the bactericidal action, and they were corroborated in this later on by Duclaux, Arloing, Roux, Geissler and others. We owe to Duclaux the theory that sunlight is the most common and cheapest disinfectant known.

Marshall Ward (189-) completed these important studies by analysing the effect of arc spectra thrown on infected agar plates; wherever they were struck by violet and particularly by ultra violet rays, they were disinfected and did not develop colonies. This English scientist sterilized Thames water by placing it in a tank equipped with a quartz window and submitting it to the rays of an arc lamp. This was proposed again later on by Lambert.

The first complete analysis of this bactericidal phenomenon of strong light sources we owe to Finsen, who in his famous light healing establishment laid the foundation of our modern knowledge of the action of light on germ life. As you will remember, the practical result of this work was the introduction of the light treatment of certain diseases by the Finsen lamp. We had, however, to await the arrival of really powerful sources of ultra violet rays before applying light practically as a bactericidal agent for the purification of water.

This new source of ultra violet rays was the mercury arc lamp built out of quartz. This mercury arc owes its origin to the work of Mr. Peter Cooper Hewitt, resulting in the well known Cooper Hewitt illuminating lamps. When the ordinary glass of these lamps is replaced by quartz glass, that is to say, fused rock crystal, we obtain a container which allows the greatest amount of the ultra violet rays produced by the mercury arc to be sent out from the lamp.

The first to propose the application of the mercury arc for the purification of water was De Mare. His sterilizer consisted of a lamp around which the water flows in a circular path (Fig. 1). Some years later and nearly simultaneously different ways of constructing water sterilizers with mercury lamps were tried out, and this work has resulted in the installation of several large and very many small ultra violet ray water purifiers.

Before going into the details of this work I will mention the principle underlying the method of water purification by ultra violet rays. We know from experiments that germs exposed directly to and at a very short distance (½ to 1 inch) from a powerful source of ultra violet rays such as we use in a modern sterilizer are killed within a small fraction of a second, in some cases one twentieth of a second being sufficient.

We therefore have to attend to two things: first, to an economic illumination of water with ultra violet rays, and second, to make sure that every microbe contained in the water will be really led through the illuminated zone.

If we consider the latter point first, we come immediately to the conclusion that nothing must be in the water to intercept the rays, that is to say, there must not be any suspended matter in the water in the shadow of which the germ would be protected from the rays emitted by the lamp.

SOURCE OF ULTRA VIOLET LIGHT

Practically every source of light emits some invisible ultra violet rays together with the visible rays. This can be studied by dissolving the light into its components by means of a quartz glass prism. Our human eye will see on such a spectrum only the well known colors of the rainbow. It will not see the wave-lengths below the red nor the wave lengths beyond the violet; however, the latter can be easily demonstrated by certain properties they have; for example, certain dye stuffs show a fluorescent color when struck by the ultra violet rays; also many chemical and physical reactions will take place under the influence of these ultra violet rays and prove their presence in the spectrum thereby.

The artificial sources of light which are richest in ultra violet rays are the electric arcs between metal electrodes, for instance, the iron arc, mercury arc, etc. All such arcing between metals is accompanied by disintegration of the metals themselves; therefore the electrodes have to be renewed from time to time. In the case of mercury this renewing can be done in the simplest and easiest manner, namely, by condensing the mercury escaping from the arc and leading the so condensed mercury back to the electrode contained. Of course, the arc in this case has to be inclosed hermetically in a container so as to avoid loss of mercury. The material we choose for making this container must be of such a quality that the desirable rays are not held up thereby, but on the contrary are allowed to escape freely. This material for the arc container is fused

* Paper read before the American Water Works Association Annual Convention at Philadelphia, and published in its Journal.

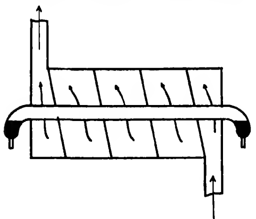


Fig. 1.—The De Mare sterilizer

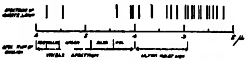


Fig. 2.—Spectrum of quartz lamp and of sunlight

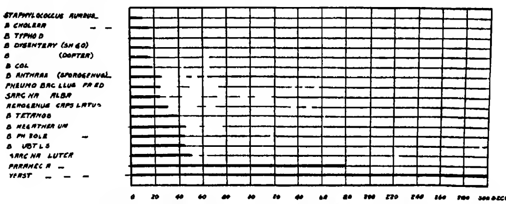


Fig. 3.—Seconds necessary to kill different types of germs at 200 millimeters from a quartz lamp burning at 66 volts, 3.5 amperes

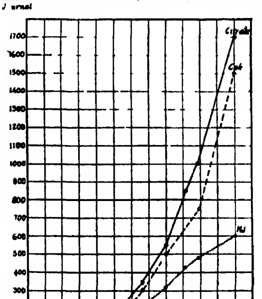


Fig. 4.—Comparative measure of ultra violet activity of 220 volt quartz lamp burning at different voltages by three methods

— decomposition of nitrate of silver; ... decomposition of iodide; — annihilation of bacterium coli.

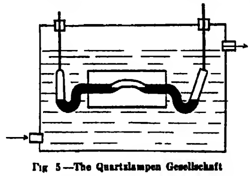
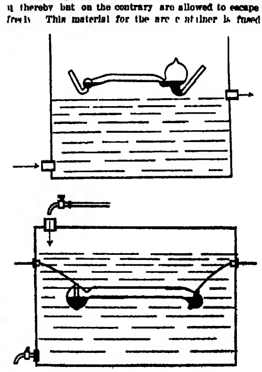


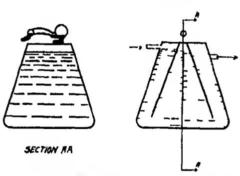
Fig. 5.—The Quartzlampen Gesellschaft



Figs. 6 and 7.—Upper figure: Apparatus used in experiments of Henri, Helbronner, and Von Recklinghausen. Lower figure: Apparatus of Nogier.

rock crystal, or more properly expressed, fused quartz.

For a given amount of electrical energy put into this arc, such a quartz arc lamp will attain a certain temperature depending upon its radiating capacity that is to say on its shape and surroundings. We have found that the amount of ultra violet rays produced by such a quartz lamp is considerably more when running at a high temperature, than when it is run at a low temperature. The production of ultra violet rays is therefore the more economical the higher the temperature of the lamp. This high temperature is obtained by raising the voltage of the lamp (Fig 4). We are however limited to a certain temperature namely about 800 deg Cent by the fact that quartz if maintained for a long time at a higher temperature will devitrify becoming thereby more or less opaque to the visible and invisible rays emitted from the arc. As in a water sterilizer we naturally want to approach the lamp as



Figs 8 and 9.—Experimental apparatus used by the writer

close as possible to the water we must be careful to consider what has just been said about temperature and prevent the water from cooling the luminous part rendering it thereby inefficient in its production of ultra violet rays.

PHYSICAL CHARACTERISTICS OF ULTRA VIOLET LIGHT

The ether vibration can be distributed in four groups according to their wave lengths namely (1) the electric rays (2) the infra red rays (3) the rays of the visible spectrum (4) the ultra violet rays.

Between the last electric rays and the first infra red rays exists probably a group of still unknown qualities. All these rays travel at the same speed namely 300 000 kilometers per second. The wave lengths are as follows

1 Electric waves (Hertz 1888) from several kilometers down to 3 millimeters.

2 Infra red rays (Herschel 1800) from 400 down to $0\ 76\mu$.*

3 Visible rays (Newton 1666) from $0\ 76\mu$ down to $0\ 40\mu$.

4 Ultra violet rays (Ritter 1802) from $0\ 40\mu$ down to $0\ 10\mu$.

We are interested to day in that last named group number 4 namely the ultra violet rays whose upper limit is more or less vague (Fig 2). It is sometimes placed at $0\ 3969\mu$ however even shorter waves can be noticed by the eye although not directly but only by the fact that the crystalline in our eyes becomes fluorescent giving thereby impression of gray on the retina. If people therefore have sometimes thought they were able to see ultra violet rays they really only saw their own crystalline. The lower limit of $0\ 10\mu$ of the ultra violet rays was obtained by Schumann and Lyman by working in vacuum with fluorspar prisms. However these very short wave lengths do not come into consideration in our case because a few millimeters of air absorb completely the wave-lengths below $0\ 150\mu$ and several centimeters of air absorb the wave lengths below $0\ 1850\mu$. Several kilometers of air absorb the ultra violet from $0\ 2943\mu$ down. This wave-length is therefore the shortest of the sun's waves reaching our eye and therefore the ultra violet contained in the sun's rays are only the wave-lengths between $0\ 40\mu$ and $0\ 2943\mu$.

* $\mu = \frac{1}{1000}$ millimeter = 10 000 Angström units.

Quartz the only material which we can apply for our lamps absorbs practically everything below $0\ 20\mu$ therefore we may say that from the ultra violet ray efficiency point of view it does not matter very much whether a quartz lamp is surrounded by a thin layer of air or by vacuum. Glass absorbs ultra violet rays to an *enormous extent*, as may be seen from the fact that the bactericidal power of a quartz lamp is cut down to 1/1 000 if the lamp is surrounded by a glass tube.

BACTERICIDAL POWER OF ULTRA VIOLET RAYS

It was of interest to see whether different microbes had different resistivities against ultra violet rays in the same way that they are different against disinfectants and heat, and we come to the astonishing result that they do not vary anything like as much. For instance spores are often twenty times as resistant as the unprotected forms of germs against chemicals. We find that some are only 1 5 to 5 times as resistant against ultra violet light as ordinarily unprotected water bacteria. The table on page 10 (Fig 3) shows a comparison of different types of germs in their resistivity. In each case under similar conditions cultures were made and the free germs put in clear water care being taken however to avoid clumps of bacteria and also to avoid the presence of the nourishing medium for otherwise the germs would have been protected more or less against the rays.

It has sometimes been thought that the bactericidal action of the ultra violet rays was due to a small amount of hydrogen peroxide which indeed forms itself by the exposure of water to the ultra violet rays. However this formation is so minute that it is barely noticeable after ten hours exposure of the water and we can surely say that the bactericidal effect is not due to the action of the so formed disinfectant but is a specific typical action of the ultra violet rays on the germ. It is not likely that by the action of the rays during such a short period the entire bacteria should be chemically changed coagulated or otherwise modified but it is more probable that some ferment or similar product contained in the cell is modified by the rays and thereby poisons the system of the cell.

We have often been asked whether the germs struck by the light may not be simply stunned and may survive again afterwards. In answer to this I will say that the methods of making the counts in Europe would enable one to find out whether there is any reviving. These counts extended over a period of usually fifteen days and never have shown any indication of revival.

QUANTITOMETRY OF ULTRA VIOLET RAYS

The luminous power of light sources is usually measured by comparing them with standard lamps. The moment that the light one wants to measure has a color different from the standard lamp great difficulties arise based on the fact that we do not really compare the two lamps physically but only physiologically.

The difficulty of determining the *ultra violet* candle-power of a lamp is far greater again as we are not sensible to these rays at all. To get some idea of the strength of ultra violet source we have therefore to *create new means and units of comparison*. Many different chemicals and physical reactions take place in the ultra violet light. One may therefore base a measure of the ultra violet candle-power on the speed and strength of such a reaction. The most typical and most convenient reaction of this kind is the blackening of photographic paper. We have found that a mercury quartz lamp will blacken paper about four times as quick as the same lamp screened behind a glass plate. An ordinary sensitometer can be built embodying this principle. Another reaction of the ultra violet rays may be considered by comparing the amount of fluorescence produced by the lamps but both of these methods of measuring will only allow us to compare light sources of similar composition. They do not give us what is really most interesting for us namely a measure of the *bactericidal power* of a lamp and we therefore thought it best to adopt a real biologic test for the measure of the abiotic strength of quartz lamps. There remains therefore nothing for us to do but to establish a standard source of ultra violet that is to say a laboratory standard composed of a certain lamp which is so kept that it is most unlikely to change in candle-power and compare the action of this lamp with the action of the lamp one wants to measure on one and the same cultures of germs. The way we proceed is as follows. We make a culture of paramecies which are very similar in their sensitivity to ultra violet rays as ordinary water bacteria. As a matter of fact they will stand about six times the exposure that bacterium coli will stand, as Fig 3 shows.

The sensitivity of such a culture is determined by exposing a drop of it at a defined distance from the laboratory standard quartz lamp. Another drop of it is exposed at the same distance to the lamp one wants to measure and the time necessary for killing gives the indication of the relative value of ultra violet candle power. We have chosen paramecies because they are easily observed under a microscope having a rather violent motion while alive and naturally no motion when dead. A few observations will therefore give us within a few minutes a definite idea of the bactericidal power one wants to measure.

I may say that we have checked figures so obtained with the effect on coli cultures and can see thereby that we have a fairly safe process for determining by comparison the ultra violet candle power of a lamp.

With all that we may say that the action on photographic papers is in most cases a precise enough indication of the ultra violet candle power as may be seen from Fig 4.

It is natural that the electric characteristics of the lamps for these measures are checked up by the usual electrical instruments indicating the amperage and voltage of the lamp.

DEVELOPMENT OF THE STERILIZING APPARATUS

The experiments we made at the Sorbonne laboratory in well as the experiments of others working in this field were started by exposing polluted water in contact with the light of the quartz lamps. These experiments allowed us to get data for the construction of sterilizing apparatus where the water was circulating continually through the illuminated zone.

As examples for the simplest form of apparatus I will

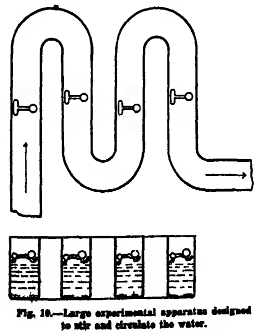
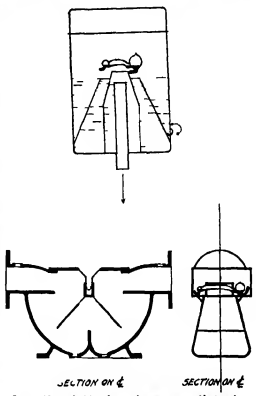
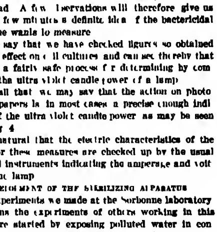


Fig. 10.—Large experimental apparatus designed to stir and circulate the water.



Figs 11 and 12.—Typical apparatus that stirs water being treated between successive illuminations



Figs 13 and 14.—Showing pistol lamp applied to flumes

in all of the sterilizing tank which we used in our preliminary experiments (Fig 6) and Nogier (Fig 7) and the Quarzlampen Gesellschaft (Fig 5) In all of these experiments the water was simply passed in a straight flow underneath or around the source of the ultra violet light We found the results with this type of apparatus to be irregular and came to the conclusion that this was due to the fact that the water although clear still contained some microscopic suspended matter which when the water was flowing straight would allow microbes to be shielded

We therefore considered it advantageous to expose the water a second and third time to the light after having stirred it between illuminations In this way we expected to turn over such microscopic particles and have them therefore exposed on all sides to the action of the lamps A typical case of such apparatus was used by us in experiments at the Sorbonne, and is shown in the design Figs 8 and 9 The water in a similar apparatus of considerably larger size (Fig 10) flowed through four illuminated zones and stirred itself up through its flow around the bends of the canal between the luminous zones The results were very satisfactory as we found sterilization from about 5 000 germs per cubic centimeter down to less than 10 per cubic centimeter the consumption of electric energy for the lamps being at the rate of 144 kilowatt hours per million gallons The submitting of the water to successive illuminations and stirring up during illumination can also be done with a single lamp by so arranging baffles that the water is led several times toward and away from the source of the light (Figs 8 and 9) Typical apparatus of this kind is shown in the B2 (Fig 11) and C3 (Fig 12) apparatus. The former apparatus B2 type uses only perhaps one fourth of the light emitted by the lamp However the apparatus is easy to handle and of a small size

The C3 apparatus was constructed in a somewhat different way with a view of using a greater proportion of ultra violet The lamp was protected from contact with the water by inserting it into a chamber fitted with quartz windows which chamber was submerged in the tank containing the water Three contacts of the water with the light are obtained in this apparatus

It was desired to so construct the lamps that practically all their light could enter into the water and exert its sterilizing action The so called pistol lamps which have a U shaped luminous tube (Fig 15) allow this to be realized the luminous part being inserted into quartz tubes which protect them from contact with the water (Figs 13 and 14) Such pistol lamp equipments can be inserted into flumes through which the water flows and give the water several successive illuminations (Figs 13 14) The necessary stirring action in the water is obtained by baffle plates placed in the lamp axis whereby fairly violent stirring is taking place near the lamp

The largest lamp unit made so far is the 500-volt 25 amperes pistol lamp and a maximum number of ten such lamps are inserted into a single flume

As to the depth of the water in sterilizing apparatus theoretically the best will be a very great depth of the water We have observed strong bactericidal action even through three feet of water the ratio being practically as may be expected inversely as the square of the distance that is to say for instance one ninth of bactericidal action at three times the distance Calculation and practice have shown us that it is good to provide if possible two feet depth of water in larger apparatus Of course in apparatus working with water which is highly colored this depth may be reduced as otherwise it would make the apparatus unnecessarily cumbersome

The whole system having been developed abroad it is only natural that there are considerably more such installations in Europe than in this country Small installations are used for producing water for drinking and surgical purposes in hospitals, schools etc also for bottling purposes The first large installation of a C3 apparatus (rate of 150 000 gallons per day) has been running since November 1910 in a suburb of Rouen The hygienic results from this plant are very satisfactory typhoid in the district fed with the water from this plant being extinct while it exists still in the surrounding districts which use similar water without ultra violet ray purification

A plant with four 220 volt pistol lamps has been running for over a year in Saint Malo sterilizing the water at a rate of 750 000 gallons per twenty four hours

Many C3 apparatus are running in France, in some cases two being run in series, with always very gratifying results The largest sterilizing unit composed of a flume with ten 500 volt pistol lamps is sterilizing the water for the city of Luneville France (Fig 16) This supply consists of 1 500 000 gallons of river water and 375 000 gallons of spring water The water in this case, which in its raw state is extremely muddy and rich in colloidal matter is filtered through a rough and slow sand filter without the addition of coagulants, at a rate of about 7 000 000 gallons per acre In case of a biological filtration this type of water would have to be filtered at the rate of 2 500 000 gallons per acre

On account of some turbidity and also an often deep color of the filtered water (up to 40 U S standard) this plant has an exceedingly high current consumption namely 130 kilowatt hours per million gallons, during most of the time two thirds of this consumption would be ample

The first application of the ultra violet ray system for sterilizing water on a large scale in this country was

Fig 15 —The pistol lamp

started recently in New York where the water of a swimming pool is continually being circulated through a rapid filter and a sterilizing flume equipped with two 220 volt pistol lamps the flow being about 5 000 gallons an hour

As mentioned in the theoretical part the ultra violet rays must be able to strike the microbe where any suspended matter is interposed the bactericidal action cannot take place because the microbe is in the shadow It is certain therefore that only clear water can be submitted to the ultra violet ray treatment for its sterilization That is to say in most cases it is necessary to filter the water before the same is submitted to the action of the lamps As color in solution will absorb ultra violet rays to a certain extent it is evidently better to also free the water from coloring material before submitting it to the rays

The question of suspended matter in the water is of somewhat greater importance Sometimes water with little suspended matter may be more difficult to sterilize than water with far more suspended matter The reason for this is that it will depend not only on the size and quantity of the suspended matter but also on its biological quality That is to say suspensions of purely mineral nature which do not inclose any microbes and to which few microbes are attached handicap the sterilization of the water very much less than suspended particles in similar water which are heavily covered with microbes and particularly so if microbes are inclosed in these particles because it is then most likely

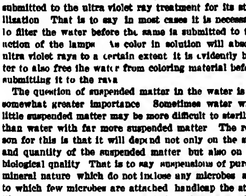


Fig 16.—Sterilizing apparatus at Luneville, France, in which ten pistol 500 volt lamps operate on one 1,500 000 gallons of water a day.

that a repeated exposure to the rays will be necessary to penetrate to the inclosed germ life

If the suspended matter is of smaller size than the germs like colloidal clay we expect such turbidity to act more or less like color in solution demanding simply more illumination than clear water Experiments made with one of the B2 apparatus on water showing up to 20 turbidity seem to prove that such fine turbidity does not handicap sterilization very much

From the economical point of view the condition in which the water is submitted to the rays is evidently of great importance for the ultra violet rays sterilization system Physically ideal water, that is to say, water without suspended matter, turbidity of color, will need very little power in ultra-violet rays to become sterile In large plants 50 kilowatt hours per million gallons will produce a great over-dose in ultra violet.

Smaller installations are being equipped usually with charcoal or paper filters. In large plants naturally the filter question is an engineering proposition, so is the question of choice between mechanical and sand filters

It seems that if the latter are chosen they can be speeded up to a great extent as against the speed for biological filtration and still give a physically pure enough water for ultra violet ray treatment as for example the Luneville plant where the water is filtered practically at three times the rate of biological filtration for that particular kind of water In other plants the filtration has been speeded up to 10 000,000 gallons to 12 000 000 gallons per acre, and we even tried with fair success 25 000 000 gallons per acre followed by ultra violet ray treatment. This will, naturally always depend on the filtrability of the water

Operating costs will vary with the size and the running hours of the plant, and the *coefficient of safety* one wants to give to the ultra violet ray treatment. According to the quality of the water I expect in large plants the current consumption will vary between 50 and 125 kilowatt hours per million gallons allowing for a large safety coefficient. The labor charges are negligible as the apparatus only needs an occasional cleaning and starting of lamps Apart from this, the lamps have to be repumped and repaired from time to time

In any engineering proposition we always try to adopt as large a *safety coefficient* as possible. If we rely on chemicals to disinfect our water we must work right close to and sometimes even over the limit of the amount which will not make itself objectionable by producing taste and odor in the water

In the ultra violet rays we have a system where we may choose *our safety coefficient as high as ever we liked* that is to say we may *over dose* our sterilization as much as we want without creating any objectionable features in the water like taste and odor

The Photokaleidograph*

An Apparatus for the Production of Kaleidoscopic Pictures

The kaleidoscope has not been used exclusively as a plaything for children. It has furnished many patterns for woven fabrics embroideries carpets and oilcloths The combination of the kaleidoscope with the photographic camera has often been attempted but with little success

In the last few years my attention has been drawn to these matters in the course of my professional work for the Carl Zeiss Optical Company We received a commission to construct a kaleidoscope of precision After overcoming certain difficulties I succeeded in producing the instrument herewith illustrated which can be used either for direct observation or for photographic reproduction of the kaleidoscopic patterns

In this instrument a solid glass prism takes the place of the two inclined mirrors of the old Brewster kaleidoscope The faces of the prism are cut accurately to the prescribed angle polished and silvered The prism is protected from injury by covering it with strips of black glass cemented to its faces The ends of the prism are cut perpendicular to the axis and polished and the prism is inclosed in a brass tube from which its ends only protrude

The tube is mounted vertically above the horizontal photographic plate measuring 13 by 18 centimeters (about 5 by 7 inches) The photographic lens is secured to the lower end of the tube. The distance of the tube from the photographic plate is adjusted to produce a sharp image and this distance is fixed by means of a stop-ring surrounding the tube Several tubes of exactly the same diameter containing prisms of different sizes and angles are provided and can easily be interchanged

The object, which is to produce the photographed kaleidoscopic pattern by internal reflection from the faces of the prism is itself a photograph on glass which is pressed lightly, with the film side down, on the upper end of the prism, to which a drop of oil has been applied. The picture is usually larger than the sectional area of the prism but only the part included in that area is reproduced and repeated on the photographic plate beneath The illumination is furnished by a mercury vapor lamp provided with a ray filter which transmits only the light of one of the violet mercury lines.

For the observation and selection of the patterns an inclined plane mirror is placed between the lens and the plate holder This mirror reflects the kaleidoscopic image to a ground glass screen which can be observed by several persons at once If it is decided to photograph the pattern, the mirror, which is mounted on a horizontal axis, is turned into a position in which it excludes light entering through the ground glass and allows the rays from the lens to fall on the photographic plate. The mirror is fastened in this position

* Translated from Dr Pulfrich's article in Die Umschau.

during the exposure of about one minute. It is then turned back to its former position in which it excludes all light from the plate and again reflects the image to the ground glass. (The entrance of light through the ground glass can also be prevented by closing a sliding shutter of sheet metal beneath the glass.)

Details of the picture may be traced on the ground glass screen. This device is often useful for the purpose of combining several kaleidoscopic pictures. A great variety of photographic transparencies may be used as objects but photographs of other kaleidoscopic patterns are especially suitable.

Each of the prisms can also be used for the direct observation of kaleidoscopic combinations. For this purpose a special observing lens is substituted for the camera lens. The other end of the tube is fitted into a base so that the prism can stand erect on a table over a drawing which is illuminated by light entering the prism laterally from below.

Fig. 1—The Photokaleidograph

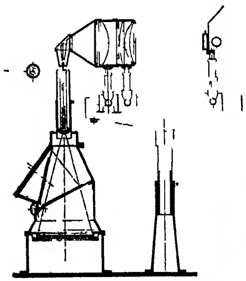


Fig. 2—Diagram of the photokaleidograph

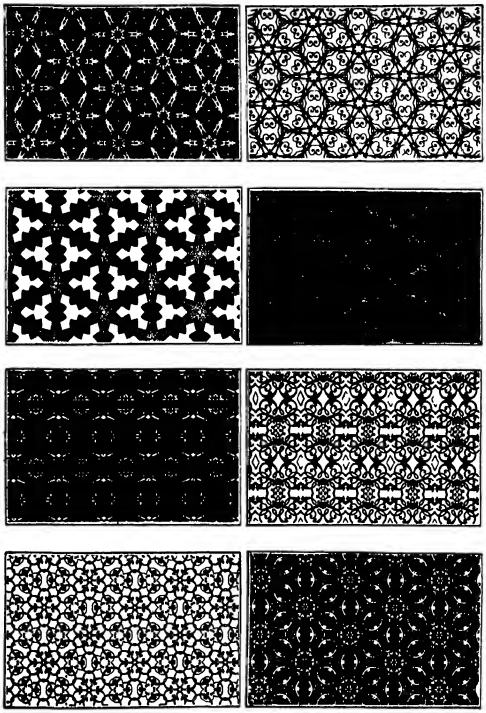


Fig. 3—Photographs of kaleidoscopic patterns

The Stars Around the North Pole*

The Determination of Their Proper and Irregular Motions

A KNOWLEDGE of distances of the stars is of fundamental importance in any attempt to describe the stellar universe. It is required before answers can be given to questions on the average distances of stars from one another, their brightness compared with the sun, and the extent to which they reach in space. There are not more than 100 or 150 stars of which the distances have been measured with any degree of accuracy. Although this number is being steadily increased it is only the stars which are comparatively near to the sun which can be treated individually. For the greater number we have to be content with average values which apply to groups of stars.

A map or a photograph of the stars gives only their bearings, that is to say their directions as seen from the earth. It gives no information whatever about the distances. One star may be a hundred times as far away as its neighbor on the map. But if two maps are made, separated by a sufficient interval of time, some differences will be found in the relative positions of the stars. These indicate movements either of the stars themselves or of the point from which they are viewed. But the movements which are observed are merely changes of angular position. We cannot tell directly from them either the actual velocities or distances of the stars but only the ratio between these quantities. It is however from the geometrical study of these small angular motions supplemented by the information obtained from the spectroscope as to the velocities of stars in the line of sight that our knowledge of their distances is derived.

The problem is in many ways analogous to one which has been completely solved. In the early days of astronomy the movements of the wandering stars or planets were noted. The essential characteristics of the movements were embodied in geometrical formulæ by the Greeks. In the course of time Copernicus showed that these formulæ could be most simply interpreted on the assumption that the earth revolved around the sun. His purely geometrical arguments were in time powerfully reinforced by the revelations of Galileo's telescope. Nevertheless the planetary system as formulated by Copernicus and Kepler resulted from the observation of the angular movements of the planets and the attempt to give them the simplest possible geometrical interpretation.

Further study of the planetary system has been guided and controlled by the law of gravitation. But the observational data on which our very complete knowledge of the solar system is based, the distances, sizes, and movements of all its members, are a long series of measures of the angular movements as seen from the earth. Linear measurements are only required to obtain the form and dimensions of the earth itself and thus supply a base line to determine the scale of the system.

The fixed stars present us with a very similar problem. From the study of their small angular movements supplemented by spectroscopic observations it is required to construct as far as possible a model of the stellar universe. Such a model would give for each star:

(1) Its actual position in space measured along three axes with the sun as origin.

(2) The velocity in kilometers a second in each of these directions.

(3) The brightness or luminosity taking the sun as unit.

(4) The mass.

(5) The size.

(6) The physical and chemical constitution.

Of these elements the mass is at present only determinable for double stars and the size for eclipsing

* An address delivered at the Royal Institution by Dr. F. W. Dyson, F.R.S.

variables The physical and chemical constitution are known from spectroscopic observations for a considerable number of stars But the distance and absolute brightness can be found only for a limited number of the nearest stars Average results can however be

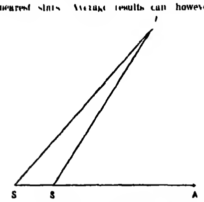


Fig 1 —Determining proper motion of stars

obtained for the more distant stars which tell us

(1) The number within certain limits of distance from the sun

(2) The mean velocities of these stars and what percentage are moving with given velocities say for example between 10 and 20 kilometers a second

(3) Whether these velocities are irregular or show anything in the nature of streaming in particular directions

(4) What proportion of the stars are comparable with the sun in intrinsic brightness and what proportion are ten times or one tenth as bright and so on

Such a description of the stellar system is to a large extent within the powers of astronomers and we nurse the perhaps extravagant hope that generalizations will be discovered which will lead to the formulation of dynamical laws on the constitution of the stellar universe

A small area round the pole has been chosen as a sample because this part of the sky has been observed more fully than any other of equal extent It forms a small cap extending to a distance of 9 degrees from the pole and covering about 1/160 of the whole sky In the year 1855-1856 Carrington an English amateur astronomer well known from his observations of sun spots using a very small transit instrument observed the positions of all the stars in this part of the sky from the brightest down to very faint stars between the tenth and eleventh magnitudes He thus constructed a catalogue giving with great accuracy the positions of 3 700 stars for the year 1855 About the year 1900 these stars were re observed at Greenwich by a combination of visual and photographic observations By comparison with the positions as given in Carrington's Catalogue the angular movement of each of these 3 700 stars in forty five years is determined These angular movements or proper motions as they are technically called are the data available for obtaining the actual positions and movements of the stars in space We have to solve the geometrical problem of making these stars stand out in three dimensions so that we may see them as we see a picture in a stereoscope

Now the proper motions of stars are very small The star of largest proper motion moves only 870 seconds a century An idea of the smallness of this motion may be obtained from the fact that it will take two centuries to move a distance equal to the apparent diameter of the sun or moon There is no star among those near the north pole with a proper motion so great as this The following table gives an abstract of the proper motions of the 3 726 stars under consideration

TABLE I

Limits of Proper Motion	Number of Stars
>40 a century	2
20′—40′	39
10 —20	134
5 10′	574
3 — 5	977
0′ — 3	2 000

It is clear that the stars with large proper motions must either be moving fast or must be comparatively near These are the alternatives but for an individual star it is impossible to decide between them

The table shows how largely the proper motions of stars vary in direction They differ just as widely in direction Some signs of irregularity in the directions were first detected by Sir William Herschel, who found that the movement of seven quick moving stars situated in different parts of the sky were approximately directed to one point. He observed that this would result if the proper motions arose not from the movement of the stars themselves but from that of the point of observation in an opposite direction, and concluded that the solar system was moving toward a point in the constellation Hercules This conclusion was not universally admitted for some time but researches by Argelander Airy Bessel and others demonstrated a regular drift among the stars such as would arise if on their otherwise irregular movements were superposed this common motion A large number of researches have been made on the exact direction of the sun's motion and it is now established with some certainty that it is toward a point in right ascension 18 hours and declination 35 degrees north not far in direction from the bright star Vega The speed of the sun's motion through space has been determined by spectroscopic observations On the average stars near Vega appear to be approaching us stars in the opposite direction to be receding from us In this way Prof Campbell has found from the observed velocities of 1,500 stars that the solar system is moving at the rate of 19 6 kilometers a second

The fact that the sun is moving with a velocity of 19 5 kilometers a second in a known direction supplies us with a means of determining the average distances of groups of stars This velocity carries the sun forward in a century a distance equal to 412 times the sun's distance from the earth If at the beginning of the century the sun is at S (Fig 1) and at the end has moved to S the angular distance of a star situated at P and having no motion of its own will have increased from ASP to $AS P$ The difference of these angles which is the proper motion of the star is SPS and it follows that the distance (SP) can readily be deduced We cannot however say that any individual star is at rest but if we take a sufficiently large group of stars it is legitimate to suppose that in the average the peculiar movements of the separate stars are eliminated and the mean distance of the group can be inferred.

During the last twenty or thirty years the proper motions of many stars have been determined by the comparison of modern with earlier observations. Particularly the reduction by Dr Auwers of Bradley's observations made in 1755 led to the accurate determination of the angular movements of the brighter stars The proper motions of fainter stars have been found by comparison with observations made in the first half of the nineteenth century These have all been utilized to determine the direction and angular amount of the drift produced in the stars by the motion of the solar system through space The results were very puzzling because different mathematical methods and different groups of stars gave widely different directions for the solar motion The cause was discovered about ten years ago by Prof Kapteyn who found in the proper motions of the stars another indication of regularity, or perhaps it might be called a systematic irregularity smaller than the one discovered by Herschel, but unmistakable when once pointed out. He interpreted these systematic irregularities to mean that the stars are divisible into two groups streaming through one another in opposite directions in space Prof Kapteyn's discovery has been submitted to mathematical analysis by Prof Eddington and Prof. Schwarzschild Their researches have illuminated the whole subject of stellar motions, and though they are not in entire agreement, they leave no doubt of the existence of a preferential movement among the stars toward the north part of Orion and the diametrically opposite direction in the constellation of the Serpent.

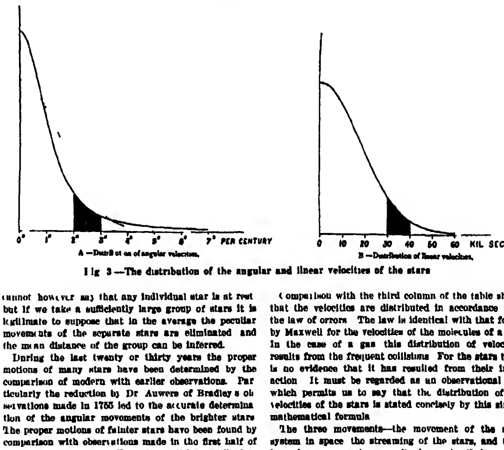


Fig 3 —The distribution of the angular and linear velocities of the stars

We must next consider the *motus peculiares*—the irregular movements of the stars themselves. From observations of the velocities of stars in the line of sight, especially from those made at the Lick Observatory under Prof Campbell's direction, it is known that a few stars are moving with great velocities, such as 100 kilometers a second, while others are moving very slowly The following analysis of Campbell's results for one class of stars—those of spectral type A—(taken from a paper by Prof Eddington) shows the proportion of slow moving moderate, and quick moving stars

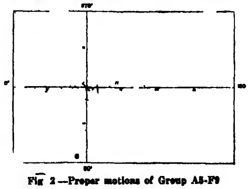


Fig 2 —Proper motions of Group A5-F9

TABLE II

Velocities	Number of Stars observed	Number of Stars given by error law
0 5 kil/sec	55	53 4
5—10	47	46 2
10 15	30	38 3
15—25	30	27 4
25—40	10	6 7
>40	0	0

Comparison with the third column of the table shows that the velocities are distributed in accordance with the law of errors The law is identical with that found by Maxwell for the velocities of the molecules of a gas In the case of a gas this distribution of velocities results from the frequent collisions For the stars there is no evidence that it has resulted from their interaction It must be regarded as an observational fact which permits us to say that the distribution of the velocities of the stars is stated concisely by this simple mathematical formula

The three movements—the movement of the solar system in space the streaming of the stars, and their irregular movements are all shown in their proper motions. The figure (taken from a paper by Mr Jones

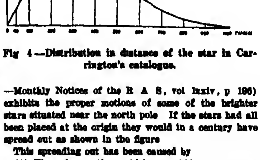


Fig 4 —Distribution in distance of the star in Carrington's catalogue.

—Monthly Notices of the R A S, vol lxxiv, p 196) exhibits the proper motions of some of the brighter stars situated near the north pole If the stars had all been placed at the origin they would in a century have spread out as shown in the figure

This spreading out has been caused by

(1) The solar motion which has shifted the center of gravity of the swarm toward 180 degrees

(2) The peculiar motions of the stars themselves, which have spread out in the directions toward 90 degrees and 270 degrees.

(3) The streaming in the direction of 0 degree to 180 degrees, which, combined with the peculiar motions, has made the spreading out much greater in this than in the perpendicular direction. In this part of the sky the

streaming happens to be in the direction of and opposite to the solar motion

Let us now consider the proper motions of the 3 700 stars observed by Carrington in the light of these discoveries. The shift of the center of gravity caused by the solar motion is 1 44 seconds a century. As we know how far the sun has moved in a century this gives the average distance of these stars as fifty million times the distance of the sun from the earth. Turning now to the proper motions in a direction perpendicular to that of the suns motion, which arise from the *motus peculiares* of the stars themselves. Counting these cross proper motions we find them divided as shown in Table III

TABLE III

16 are greater than	1' 0 a century	
35 lie between	10 0 and	15 0 a century
33	8 0	10 0
86	6 0	8 0
191	4 0	6 0
873	2 0	4 0
2504	0 0	2 0

When suitable allowance is made for the accidental error in these observations, it is found that the number less than any given amount r can be represented by the following algebraical formula

$$\frac{r}{3\,700\,\sqrt{(r^2 + 1\,17)}}$$

The distribution of the angular velocities is shown in Fig 3 (A) the total number being represented by the area of the curve the number for example between 2 seconds and 3 seconds a century is given by the shaded portion

Now suppose that all these stars were actually moving with the same velocity, say 10 kilometers a second then their distance could be calculated those with proper motion 1 second a century being forty million times as distant as the sun those with proper motion 2 seconds a century twenty million times those of 4 seconds a century ten million times and so on the larger the proper motion the nearer the star to us

This is only an illustration the velocities of the stars are not all the same but are distributed according to the law of errors. If the distance of each star were known then by dividing the velocity by the distance the proper motion would be found. We have to find how many are at one distance how many at another so that the proper motions will be distributed in accordance with the law found from the observations

Fig 3 (B) shows the distribution of linear velocities the shaded portion for example giving the proportion moving between 30 and 40 kilometers a second. Now the distribution of angular velocities is shown in (A) and the question arises How must the stars be distributed in distance for these two laws to harmonize?

This is a mathematical problem which can be solved fairly easily and the answer is that the stars must be distributed in distance according to a law shown graphically by the curve in Fig 4 (The distribution of velocities $\frac{h}{\sqrt{\pi}}\,e^{-h^2v^2}\,dv$ combined with the distribution of proper motions $\frac{dr}{a}\left(1+\frac{r^2}{a^2}\right)^{-\frac{3}{2}}$ leads to the partial distribution $2a^2h^3r\,e^{-h^2r^2}dr$)

In the diagram distances are measured horizontally the unit of distance being that at which a star's parallax is equal to 1 second (or 206 265 times the distance of the earth from the sun). It is convenient to have a name for this unit and in what follows the word *Parsec*, suggested by Prof Turner, will be adopted. With this unit a distance of 100 in the diagram denotes twenty million times the distance of the sun from the earth. The following table gives the percentage of stars between certain limits of distance

TABLE IV

5 per cent of the stars are between	0 and 100	100 parsecs 200
10	200	400
45	400	700
36		>700

It follows that 58 per cent of the stars in Carrington's Catalogue that is, 58 per cent of all the stars brighter than about 10 5 magnitude, lie between 20 and 150 million times the distance of the sun from the earth. This law of the distribution of the stars is at first sight rather surprising. It should be remembered that the only stars at a great distance which are included are those which are intrinsically very bright, and these form only a small proportion of all the stars. Prof Eddington has found that a similar law holds for stars brighter than 6 0 magnitude

Having found the law of distribution of the distances of these stars, it is not difficult to determine something about their absolute luminosities, i e, how they would compare with the sun in brightness if placed at an equal distance from us.

If the sun were at a distance of one *parsec*, it would appear as a bright star, brighter than the first magnitude—actually of magnitude 0.5; if at a distance of 100 parsecs, its magnitude would be 10 5. Now all the stars in Carrington's Catalogue may be taken as brighter than 10 5 magnitude thus at least 95 per cent of these stars are intrinsically brighter than the sun and at least 80 per cent are four times as bright 40 per cent are sixteen times as bright and 8 per cent are fifty times as bright

We may conclude that the great majority of the stars brighter than 10 5 magnitude are intrinsically brighter than the sun and a considerable proportion very much brighter

The distribution of bright and faint stars in a given volume of space is quite different and contains a much larger proportion of faint stars. If we make the assumptions that the density of the stars and the proportions of bright and faint ones is the same at the different distances from the sun within which these Carrington stars are situated it is possible to find the actual number of stars of different luminosities in a given volume of space. In a sphere with radius 100 parsecs, or twenty million times the distance of the earth from the sun there are at least

24 which are	100 times as luminous as the sun
340	50
1 530	5
4 840	10
23 300	1
91 300	1 10th the luminosity of the sun

The data only admit of a rough determination of the number of very faint stars and the number of very bright ones. The figures give a general indication of the density of the stars in space and of their intrinsic brightness and serve to direct attention to the fact that there are many stars much less luminous than the sun and a certain proportion very much more luminous

The conclusions drawn up to this point have been based entirely on a consideration of the proper motions of the stars irrespective of whether they are bright or faint provided only that they are sufficiently bright to have been observed by Carrington. But as the apparent magnitude of a star depends on its distance as well as on its intrinsic brightness we naturally expect some assistance in assigning the distances of these stars from their magnitudes. The brightest star in this small area round the north pole is Polaris the magnitude of which is 2 (It may be remarked incidentally that the distance of the pole star has been actually measured. It is twenty parsecs or four million times the distance of the sun from the earth and if it were at the same distance as the sun it would appear to be 100 times as bright.) Then there are about twenty stars which are visible to the naked eye. The following table gives the actual number of stars of different magnitudes (photographic)

TABLE V

Brighter than	7 0m	11 stars
From 7 0m to	8 0m	1 4
8 0m	9 0m	39
9 0m	10 0m	995
Fainter than	10 0m	2 140

Then again the stars may be divided into groups according to the physical characteristics revealed by the spectroscope. The researches of Kapteyn Campbell and others have shown—at any rate for the brighter stars—remarkable relationships between the distances and velocities of the stars and the type of spectrum which they manifest. It is therefore desirable to examine the proper motions of stars of different spectral types separately. The spectra of many thousands of stars have been determined at Harvard College under Prof Pickering's direction by Miss Cannon. The different classes are indicated in the Harvard classification by the letters B A F G K M with further subdivisions. The B stars are characterized by the presence of helium the A stars by series of broad hydrogen lines. In the F stars the hydrogen lines are thinner and fine metallic lines are shown. The G stars are very like the sun full of metallic lines and with broad lines due to calcium. In the K stars the two calcium lines are still broader and there are many fine metallic lines. The M stars are characterised by broad absorption bands. This arrangement places the stars in the order of their temperatures, the B stars are the bluest and hottest, and the M stars the reddest and coolest. The character of the spectra of about 800 of the stars in Carrington's Catalogue is given by the Harvard observations

For the fainter stars the spectra have not been determined but they can be inferred in another way. As the blue stars are more active photographically than the red stars if a red and blue star have the same visual magnitude the magnitudes estimated from the images on a photograph will differ considerably and this difference is an index of the color and thus of the type of spectrum. Now the visual magnitudes of most of these faint stars have been very accurately determined at Potsdam by Messrs. Müller and Kron (and have been kindly communicated in manuscript) and the photographic magnitudes have been determined at Greenwich. The differences have been taken between the photographic and visual magnitudes and serve to classify the stars according to their temperature

Separating the stars into two groups those which are brighter than 9 5 magnitude on the Potsdam scale of magnitude, and dividing each group into four classes according to the color index the parallactic motion i e the mean angular movement per century arising from the motion of the sun through space is determined for each class. The results are exhibited in the following table

TABLE VI

Spectral class	Color index	Stars brighter than 9 5: Number	Parallactic motion	Stars fainter than 9 5: Number	Parallactic motion
K M	> 8	1	0 0	60	0 38
K	4 8	198	1 31	428	0 95
F G	1 4	54	3 8	950	1 53
A F	< 1	240	1 97	460	1 28

In this table the red stars are on the top line the third line consists of stars which are in the same stage of development as the sun those in the second line are somewhat cooler and redder those in the last line hotter and bluer. The last line includes a few but only a few B stars as there are not many in this part of the sky. The quantities in the fourth and sixth columns of the table are a gage of the distance of the stars to which they refer. It is only necessary to divide these into 3 7 seconds which is the angle through which a star distant 1 parsec would have been displaced in the solar motion in one hundred years to obtain the distances in parsecs. Thus the 240 stars belonging to types A F and brighter than 9 5 magnitude are at an average distance of 170 parsecs

The first point to notice is that parallactic motions of stars fainter than 9 5 magnitude are always considerably less than the corresponding quantities for stars brighter than 9 5 magnitude. This is of course because the faint stars are on the whole further away. The average distance of stars of magnitude 10 0 is approximately 1¼ times as great as for a star of 8 0 magnitude

The next point is the very great distance of the red stars. The 60 faint red stars are very nearly 1 000 parsecs away or 200 million times as distant as the sun. At this great distance the sun would appear as of magnitude 15 5 but these stars vary in magnitude from 9 5 to 11 0 and are therefore intrinsically from 250 to 63 times as bright as the sun. Now it happens that among the stars nearest to the sun the distances of which have been actually measured there are several red stars and these are all very much fainter than the sun. It has been suggested by Prof Russell and Prof Hertzsprung independently that the red stars are of two distinct classes which they call the giants and the dwarfs and that in accordance with Sir Norman Lockyer's views the giant red stars are in an early stage of evolution and are increasing in temperature while the dwarf stars are at the other end of the series and are growing colder and darker

Leaving the red stars it is seen that the stars the color indexes of which lie between —1 and +4 are nearer to us than the groups on either side of them. These stars are those the spectra of which are of the types F and G in the Harvard notation and are the stars most like the sun. The mean distances of these stars is only 130 parsecs for the stars brighter than 9 5 magnitude and 215 parsecs for the stars fainter than 9 5 magnitude. At this distance the sun would be of magnitude 12 1. It follows that these stars are on the average from two to eight times as bright as the sun. The A F stars are a little but not much farther away the stars fainter than 9 5 magnitude being at an average distance of 281 parsecs. At this distance the sun would have a magnitude of 12 5 and these stars are from sixteen to four times as luminous as the sun

It has been shown how the knowledge that the solar system is moving in a known direction with a velocity of 19 5 kilometers per second leads to a determination of the distances of groups of stars the angular movements of which are known. The hypothesis made is that in a number like one hundred or two hundred stars the irregular angular movements due to the motions of the stars themselves neutralize one another on the average. But this is only the mean distance of the group and some are much nearer and some much farther. The distribution of the stars about this mean distance may be derived from the proper motions if we know how the linear velocities are distributed. I shall apply this method to the group of stars which are like the sun in type of spectrum and therefore presumably of like temperature and physical constitution

Dividing these into three classes according to their magnitude it is found that their parallactic motion due to the sun's movement and their average motion in the perpendicular direction due to their own peculiar movements are as follows

	N	Parallactic motion	Av cross motion	Ratio
All stars down to 11 0m	1 247	1 92	±1 67	0 87
Stars brighter than 10 0m	470	2 50	+2 10	0 84
Stars brighter than 9 0m	148	3 34	+2 90	0 87

In the last column is given the ratio of the average cross motion to the parallactic motion The agreement of the numbers shows that the bright stars and the faint stars have the same average velocity. Taking the velocity of the sun as 19.5 kilometers a second, it follows that the average velocity of these stars in the direction perpendicular to the sun's motion is 13.7 kilometers a second

We shall now make the assumption that some of these stars are moving faster than this velocity and some slower, just as errors of observation are distributed about a mean error With a mean velocity of 13.7 kilometers a second, there will be in 1,000 stars

211	with velocities	0 to	5 km/sec
208	"	5 "	10
175	"	10 "	15
141	"	15	20
103	"	20 "	30
59	"	30	40
18	"	40 "	50
1	"	"	>50

If now the observed proper motions are arranged, it is found that the number less than any value τ can be represented satisfactorily by an algebraic formula

$$N \frac{\tau}{(\tau^2 + a^2)^{\frac{1}{2}}}$$

mean value of τ. The following table shows the actual number of stars with proper motions between certain limits, compared with the number given by the formula:

TABLE VII

Limits of proper motion	No. of stars observed	No. given by formula	Difference
0" to 1" a century	427	429	−2
1 " 2 "	346	337	+9
2 " 4 "	424	332	−8
4 " 7 "	105	103	+2
7 " 10 "	25	22	+3
>10 "	20	19	+1

We may take it that the formula substantially represents the observed facts With the proper motions distributed according to this formula, and the actual velocities distributed according to the law of errors, the distribution of the stars in distance can be determined, and it is found that these 1,247 stars are distributed in space as shown in Table VIII.

TABLE VIII.

NUMBER OF SOLAR STARS (TYPES F AND G) AT DIFFERENT DISTANCES.

Distance (parsecs)	Out of total 1,247 stars	Out of 470 stars brighter than 10.0m	Out of 148 stars brighter than 9.0m
<100	121	76	40
100—200	298	101	65
200—300	332	136	34
300—400	254	68	8
400—500	146	23	1
500—600	65	5	
600—700	25		
>700	5		

The most remarkable feature of this table is that 70 per cent of the stars lie between the narrow limits of one hundred and four hundred parsecs.

I have treated the 470 stars which are brighter than 10.0 magnitude and the 148 brighter than 9.0 magnitude in a similar manner. The results are given in the third and fourth columns of Table VIII. Taking the differences, the distribution in distance of the 777 stars of magnitude is 10.0-11.0 and of the 322 stars of 9.0-10.0 magnitude is found.

To compare the intrinsic magnitudes of the stars it is convenient to take limits of distance in geometrical progression with a common ratio 1.259 (log = 0.1), e. g., 40, 50, 63, 79, 100, 126, etc., parsecs. These limits correspond to a change of half a magnitude in the intrinsic brightness of the stars which are of the same apparent brightness. Confining our attention to the stars of apparent magnitude 10.0 to 11.0, or, speaking broadly, stars of 10.5 magnitude, the limits 50-63 parsecs contain stars half a magnitude brighter, and distributed over twice the volume of those contained between the limits 40-50 parsecs

If we may assume that the actual density of the stars is the same in all parts of the space with which we are dealing, we obtain by reasoning of this kind the number of stars between different limits of absolute brightness The following table shows the number of stars of different luminosities in a sphere of one hundred parsecs radius

Luminosity =1	No. of stars 10.0m - 11.0m	No. of stars 9.0m - 10.0m
0.40 to 1.0	16 000	18 000
1.0 " 2.5	9 300	11 300
2.5 " 6.3	5 700	7 900
6.3 " 16	2 570	3 600
16 " 40	502	1 040
Brighter than 10	14	68

The results in the second column have been obtained by considering the faintest stars, those from 10.0 to 11.0 magnitude If the class brighter is taken, those stars which appear to be of magnitudes 9.0 to 10.0, we find in a similar way the quantities given in the last column.

There is an increasing divergence between the results. Now it is to be remembered that these figures have been derived from regions at different distances from the sun. Thus the stars which are between sixty and forty times the brightness of the sun, and which are apparently of magnitude 10 to 11, lie between 398 and 631 parsecs, while those which are apparently of 9.0 to 10.0 magnitude lie between 251 and 398 parsecs.

We may conclude, therefore, that the density of this class of stars is somewhat less at this greater distance from the sun. Following out this line of reasoning, I have found the diminution of density of the stars to be as follows:

Distance	Density	Distance	Density
At 50 parsecs	1.30	At 300 parsecs.	0.48
" 100 "	1.00	" 400 "	0.32
" 200 "	0.70	" 500 "	0.21

Although much weight cannot be attached to the exact figures, one seems justified in saying that there must be a very considerable falling off in the density of the stars between the distances of 100 and 500 parsecs A falling off in the total density of the stars would affect the tables giving the proportion of stars of different brightness, and would increase considerably the proportion of bright stars.

Although the conclusions presented in this paper have been derived from a study of the proper motions of the stars in a small area of the sky, and may be somewhat modified by the investigation of other regions, they may be considered as fairly applicable to the stars in general. The limiting magnitude of the stars that have been considered is nearly 11.0 (on the Potsdam scale), and there are, in the whole sky, half a million stars brighter than this limit of magnitude.

It may be said of them that:

(1) On the whole, the yellow stars, the stars like the sun in physical conditions, are the nearest.

(2) They lie within fairly narrow limits of distance —80 per cent are between 100 and 500 parsecs, 10 per cent nearer than 100 parsecs, and 10 per cent farther away than 500 parsecs.

(3) Going from the yellow to the blue or the orange stars, the average distances increase.

(4) The red stars are at great distances—an average of about 1,000 parsecs.

(5) The stars vary greatly in *intrinsic brightness.* The red stars are specially luminous, being on an average one hundred times as bright as the sun.

(6) Considering all the stars down to this limit of magnitude, from 90 to 95 per cent are intrinsically more luminous than the sun.

(7) When, however, the luminosity of the stars in a given volume of space is considered, there are found to be far more faint than bright stars. There is no contradiction between this conclusion and the last one, because the more distant bright stars are visible, while we only see the faint ones which are comparatively near.

(8) Evidence has been found that the stars thin out very materially at great distances from the sun

These conclusions are in harmony with the conception of a finite stellar universe. Most of the stars we see, and a great many fainter ones, are within the distance of 1,000 parsecs Doubtless the stars extend to much greater distances, perhaps ten times as far or farther, but we can scarcely doubt that we are near the middle of a finite group of stars, and that the extent of this group is of the order of 1,000 to 10,000 parsecs

Another System of Generating Electricity

ONE of the latest propositions for producing electricity commercially is the application of thermo-electric couples placed around a heated flue. These couples are composed of an element made of a special alloy and a copper-nickel element. These elements are separated by a layer of mica insulation and are joined together at their hot ends by a band of electrolytically deposited copper. Five of these elements are connected together in series to form a unit, and a suitable number of these units, which are wedge shaped, are formed into a ring that surrounds the heated flue, from which it is insulated by an interposed layer of mica to prevent short circuiting the units. The unheated ends of the elements are kept cool by circulating cold air around them. It is said that the cost of installing such a sytem, as compared with steam, gas and oil operated engines, is as 13 compared to 26, 30 and 38, respectively, while the cost of producing electricity by this arrangement compares with the above sources as 5.6 to 24, 16.5 and 19.3, respectively, not taking into consideration the cost of depreciation or attendance of the steam, gas and oil plants.

Dr. Bose's Visit to America

PROF. J. C. BOSE, whose discoveries regarding the continuity of physiological response in the plant and animal created great interest in England and the Continent, is now in America on scientific mission from the British government. Prof. Bose will exhibit his resonant recorder at Philadelphia before Section G of the American Association for Advancement of Science on the 29th of December. This instrument records time intervals as short as the thousandth part of a second, and measures the perception time of a plant. On the 11th of January Prof. Bose will give a discourse on "Plant Autographs and Their Revelations," illustrated by original experiments, before the Academy of Sciences, New York. Before his return to Europe Dr. Bose will lecture before the Columbia University, the Academy of Sciences, Washington; the Philosophical Society of Philadelphia, the Twentieth Century Club, Boston; the Universities of Chicago, Wisconsin, Illinois, and Michigan.

Locomotive Headlights

IT is stated by an authority on the subject, that the intensity of the head-light of a locomotive should not be greater than fifteen to twenty candle power per square inch of its projected area, hence a lamp of 3,000 candle power, with a 16-inch reflector, will give an illumination within the maximum limit. The chief function of a head-light is to warn persons ahead of the approach of the train, as no commercially practical light would enable the engineer to see a dark object, like a man, more than 500 feet. The light, however, serves as a warning in many cases at a distance of 25 miles, and it is also useful to the engineer in distinguishing landmarks, whistle boards and similar objects.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JANUARY 2, 1915

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year	$5.00
Scientific American (established 1845) . . . . "	3.00
American Homes and Gardens . . . . "	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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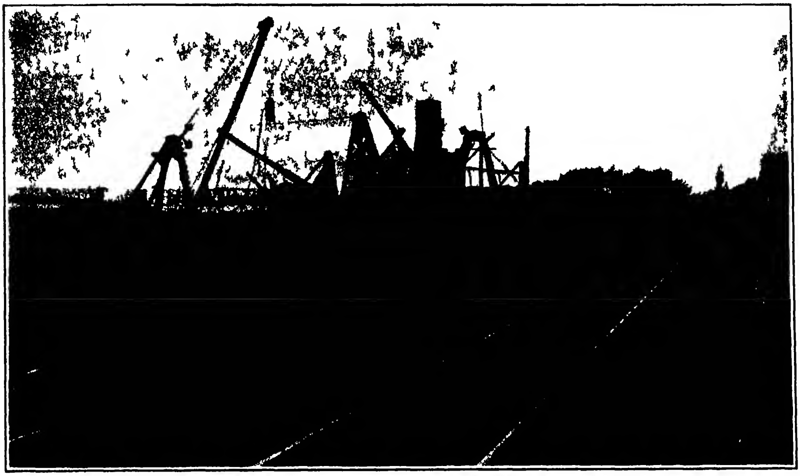
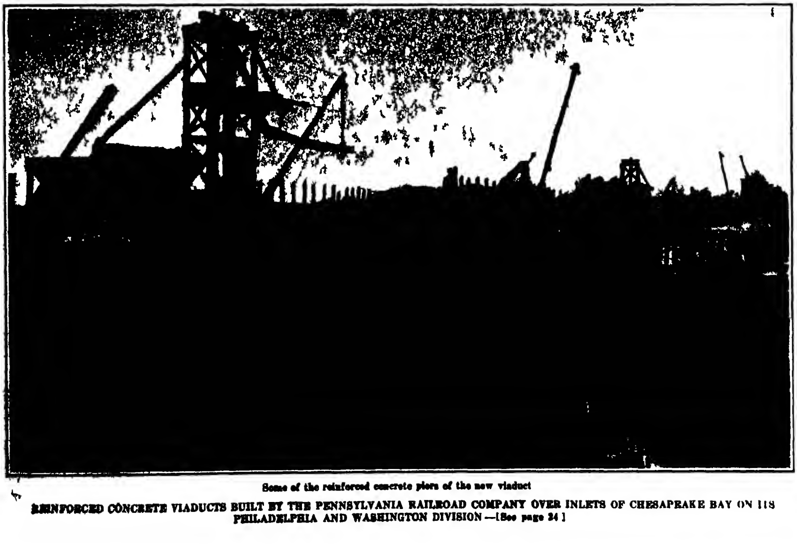
VOLUME LXXIX NUMBER [illegible]] NEW YORK JANUARY 9 1915 [0 CENTS A COPY $5.00 A YEAR



One of the old wooden trestles that have been replaced by a substantial masonry struct re



Some of the reinforced concrete piers of the new viaduct

REINFORCED CONCRETE VIADUCTS BUILT BY THE PENNSYLVANIA RAILROAD COMPANY OVER INLETS OF CHESAPEAKE BAY ON ITS PHILADELPHIA AND WASHINGTON DIVISION.—[See page 24]

Experiments in Hybridizing Japanese Flowers

Which Appear to Show a Variation in Mendel's Law

By Walter Proctor Jenny, Ph.D.

The results of these experiments in hybridization are due to the discovery made early in the progress of the work, *that the dry pollen of the white moonflower, applied to the stigma of the morning glory, is inert and will not fertilize the ovary, unless the pollen be wet with the dew-like fluid excreted upon the surface of the stigma of the moonflower.*

The purpose of this article is to place upon record the results of experiments conducted for a term of years, at private expense, at my home in the city of Washington, D. C., an investigation undertaken and carried out owing to my interest in plant breeding—an interest stimulated by the fascination that attends the creation of new and beautiful flowers.

The method followed departs so widely from the usual procedure in hybridizing, and the results obtained are so exceptional, and offer such broad as well as important possibilities in the creation of new types, that they can scarcely fail to prove of interest to other workers in this field.

That the natural stigmal fluid of the moonflower, namely, the dew-like excretion deposited upon the surface of the stigma, when in readiness for self-fertilization, is also essential to the development of its pollen in the fertilization of the ovary of the morning glory, was discovered in this way. In my first attempts, I removed the anthers from the flowers of the morning glory, and then applied the pollen of the moonflower, using the reflexed flower as a brush. Some twenty-five flowers were thus pollenated, but only one produced seed. In the following season, 1912, I pollenated nearly 200 flowers of the morning glory, applying the pollen of the moonflower in different ways, without obtaining seed in a single instance; this was before I found that the stigmal fluid of the moonflower was needed in order that fertilization of the ovary might take place. In attempting to reverse the process and pollenate the moonflower with the pollen of the morning glory, I noticed the way in which the pollen grains adhered to the moist stigma of the moonflower, and with only the thought to make the pollen adhere more perfectly, I tried the experiment of transferring this excretion of the stigma to the stigma of the morning glory before applying the pollen of the moonflower. Several flowers of the morning glory were depollenated, and the stigmal fluid, together with the pollen of the moonflower, applied. A few days later, on examining these hybridized flowers, it was seen that fully one half of the flowers had commenced to develop seed. From this time on, the stigmal fluid of the moonflower was employed in all experiments in crossing these flowers.

The flowers experimented with are of different genera of *Convolvulaceæ*, namely,

1. "The early blooming white moonflower," *Calonyction speciosum*, with black seed, said to be a cross between *C. Mexicana alba* and *C. grandiflora alba;* it has been in cultivation a number of years; and

2. Numerous varieties of the Japanese morning glory, *Ipomœa Chinaensis*, having flowers in many shades of red, rose, lilac, violet, purple, and blue, and also pure white.

Natural hybrids of the white moonflower and the morning glory do not appear to take place. I have, however, observed that the Japanese morning glory and the American morning glory will occasionally cross, where growing near to one another.

The flowers were grown in 12 to 14-inch pots, in the open air; the vines being trained upon trellises of bamboo and wire.

In the following statement, no attempt is made to give particular instructions to be followed, but rather to set forth what was done to produce the hybrid Ipomœa I have named *Bansai*.

All hybridizations that produced seed were made with the white moonflower as the male parent and the Japanese morning glory as the female. A number of attempts were made to reverse the process, applying the pollen of the morning glory to the stigma of the moonflower; but all failed to set seed. All hybrids and cross-bred plants described produced fertile seed.

The morning glory blooms in the early morning, often before daylight, while the moonflower blooms soon after sunset; so that to obtain a supply of moonflowers for hybridizing, it is usually necessary to gather the flowers soon after they open, and before they have been visited by insects, and to preserve them in shallow dishes of water in an ice chest. Where no insects are present the moonflowers may be let to remain on the vine and to be picked at early dawn, at the time the hybridization is performed. In my experiments no risks of insect interference have been allowed.

The flower selected for the female parent has first its pollen removed by the application of a fine stream of water—the excess of water is drained out and the flower dried by gently applying slender slips of blotting paper (following the method published by Mr. George Oliver, Department of Agriculture, Washington, D. C.).

I perform the hybridization as follows: I take a moonflower, reflex the flower and pull off the stamens, leaving the stigma intact. The stigma of the moonflower is then applied to the stigma of the morning glory, gently rubbing them one upon the other, so as to transfer the dew-like moisture upon the moonflower stigma to the stigma of the morning glory. This is repeated two or three times, using a fresh moonflower for each application. Then select a moonflower with ripe pollen, reflex the flower and holding it so that the *stamens are loosely bunched together, insert the* stamens in the tube of the morning glory, with the stigma of the morning glory in the midst of the anthers that is, the stigma of the morning glory is surrounded on all sides by the anthers of the moonflower; a slight movement, in and out of the stamens, at the same time rotating the moonflower, transfers the pollen to the wet stigma of the morning glory, to which it adheres. This application of pollen is repeated with one or more fresh moonflowers. The flower is then closed (like an unopened bud) and tied at the tip with yarn, to exclude insects—about 40 per cent of the flowers thus hybridized produce seed.

Sometimes I vary this method by first wetting the stigma of the morning glory with the vitalizing fluid of the moonflower and then alternately applying the anthers and the stigma of the moonflower, gently rubbing in the pollen with successive applications of the stigmas of fresh moonflowers, until the stigma of the morning glory is loaded with the adhesive coating of pollen.

The first hybrid that I obtained was Bansai, a flower of rare beauty, with a deep carmine center, margined by pure white. It was at once recognized as constituting a new type; of vigorous growth, and what was most important, the flowers had good keeping quality and did not wilt or change color, if shielded from the sun, even in the heat of summer. The great drawback with all morning glories, both Japanese and American, is the lack of permanence in the flowers, which either wilt or change color soon after sunrise.

Bansai was produced as follows: In the summer of 1911, a red Japanese morning glory was selected as the female parent and hybridized with the pollen of the white moonflower, as follows: the flower was depollenated and the pollen of the moonflower applied by employing the reflexed flower as a brush. It is supposed that in this solitary instance, some of the stigmal fluid of the moonflower was transferred in the process of pollenation to the stigma of the morning glory. This hybridization was made more than a year prior to the discovery that the stigmal fluid was essential to the development of the pollen in the fertilization of the ovary. As stated, only a single flower thus pollenated produced seed. In 1912 this seed was planted in a flower pot (12 inches in diameter) and early in July the new hybrid bloomed, and its self-pollenated seed was saved. A few flowers of Bansai, as an experiment, were again crossed with the pollen of the white moonflower; the procedure, employing the stigmal fluid, as described, was varied in that the pollen of the Bansai flowers was not removed. Several flowers, thus at once self-pollenated and reinforced with the pollen of the moonflower, produced seed.

In 1913 these two lots of seed were planted under like conditions; but from germination to maturity, the plants that were twice crossed with the moonflower were the most vigorous in growth and their flowers were more nearly true to type. For this reason, these plants that had been reinforced by inbreeding with the moonflower were selected to carry on the strain and marked Bansai No. 2.

The diagram attached hereto shows graphically the several steps followed in the seasons of 1911, '12, '13, and '14, in originating and in fixing true to type the hybrid morning glory Bansai.

The self-pollenated seed of Bansai, No. 1, produced eight plants in the second generation (1913), that were carefully watched during growth. None of these seedlings appeared to conform to Mendel's law, in resembling the male parent, more than did the original hybrid Bansai, No. 1, the female parent continuing dominant. There was, however, a noticeable decrease in the vigor of growth, compared with Bansai, No. 1, notwithstanding that the soil was rich and growth stimulated by watering with liquid fertilizers. The flowers were also somewhat smaller in size, and a tendency was observed to eliminate the white border.

About this time, the results of other experiments with these flowers indicated that this reinforcement of a hybrid, by inbreeding with its male parent, might be improved upon, by first depollenating the hybrid flower and treating the stigma with the developing fluid of the moonflower, as described, then applying the pollen of a number of flowers of the same hybrid, and finally rubbing in the pollen of the hybrid, using to do this both the anthers and stigma of two, or often three, moonflowers, thus in one operation fertilizing the hybrid flower with the pollen of flowers from the same plant, or preferably, with the pollen of selected flowers from another plant of the same hybrid, and blending therewith not only the vitalizing fluid of the stigma of the moonflower, but the pollen of the moonflower as well.

This method of dual fertilization was employed in the season of 1913 in the endeavor to fix Bansai No. 2 true to type, with the result that fully 50 per cent of the flowers so treated produced seed.

Diagram of the multiple hybridizing of a Japanese morning glory with the pollen of the white moonflower in producing the original hybrid and in the successive repollenations whereby the hybrid flower is made to reproduce itself true from seed, and has imparted to it an increased vigor of growth.

SEASON OF 1911.

Male Parent.
White Moonflower

Female Parent.
Red Japanese Morning Glory.
Depollenated and the pollen of the moonflower applied, by employing the reflexed flower as a brush.
It is supposed that in this instance some of the stigmal fluid of the moonflower was transferred in the process of pollenation to the stigma of the morning glory.

SEASON OF 1912.

Original Hybrid.
Bansai, No. 1
First Generation
Pollen not removed. Stigma treated with stigmal fluid. Finally repollenated with pollen of the moonflower.

SEASON OF 1913.

Bansai, No. 2.
Second, First Generation.
Depollenated. Stigma treated with stigmal fluid. Pollenated with the pollen from other plants of Bansai, No. 2. Finally repollenated with pollen of the moonflower.

SEASON OF 1914.

Bansai, No. 3.
Third, First Generation.

These seed, planted in 1914, produced Bansai, No. 3, the result of twice inbreeding the original hybrid with itself and with its male parent—in fact, Bansai No. 3 may be looked upon as *the third, first generation, of the original hybrid*. That no true second generation, or second year's growth, took place, counting from the year that the hybridization was performed, is of interest in its possible relation to the operation of Mendel's law.

The successive pollenations of the original hybrid with the moonflower caused a notable increase in vigor of growth, the leaves becoming broader and the white border of the flowers more prominent—in fact, the cumulative effect was to accentuate those qualities that appear to have been derived from the moonflower.

In Bansai, as thus developed and fixed, the female parent is dominant; it has inherited from the moonflower vigor of growth and increased substance in the flowers—the flowers are also marked by a white border; in all else, Bansai seems to inherit from the morning glory. Owing to the greater substance of the flowers and the marked permanence of the color, the flowers keep well; in this respect Bansai is superior to either parent. If picked early in the morning, the flowers may be kept in an ice-chest (at a temperature of about 55 deg. Fahr.) for 24 hours. On cloudy days, the flowers of Bansai remain on the vines without closing until

after sunset. The buds are long and large, and the flowers as they naturally open measure 3 to 4¼ inches across. The largest flowers I have raised measured 4¾ inches across, without touching the flower in any way to enlarge it.

Bansai may truly be termed the first of a new type of morning glory. It is strong and vigorous in growth, the vines attaining with five months' growth from seed a height of 25 to 35 feet. The leaves are 6 to 8 inches long, shaped like an aeroplane, often with two pairs of wings in the same plane, situate near the axil of the leaf. The flowers are borne profusely, and have a brilliant carmine center with a margin of pure white one fourth of an inch broad. The color appears to be due to a dye filling the cells of the flowers; it is extracted by macerating the flowers in alcohol. The solution is of a clear carmine color, and reacts with acids and alkalies like litmus—changing to blue with alkalies and red with acids.

The method here set forth was tested in the season of 1913, with other varieties of the Japanese morning glory. In 1914 the seed of these hybridizations was planted, producing a number of new flowers of the Bansai type. It was noted that various shades of lavender, rose, blue, and purple, yielded when hybridized with the white moonflower new varieties, having the center of the color of the female parent, with a border of pure white, in this resembling Bansai. It is suggested that these new hybrids, in which the female parent is so uniformly dominant, constitute a new type, distinguished from normal hybrids in that the male parent has exerted only an influence upon the resultant hybrids. Should this view be confirmed by further study, they might be designated as *influence hybrids*. Other experiments, in which the morning glory was subjected to dual pollenation, the pollen of a different variety of morning glory being mingled with the pollen and stigmal fluid of the moonflower, resulted in many new and surprising hybrids; some with new colors, widely variant from the flowers from which they had been derived. Some of these new hybrids will be preserved and further cultivated to observe the results in future generations.

In conclusion: hybrids of the Japanese morning glory with the white moonflower seem not to be subject to the operation of Mendel's law or are only subject to it in a limited way; this may be owing to:

1. That for some reason, the white moonflower is immune from the influence causing the seedlings of hybrid plants to vary in the second year. In this connection it is worthy of note, that crosses of the Japanese and American morning glory, arising from pollenation by insects, follow Mendel's law.

2. That this exemption is due to some quality or property of the fluid excreted by the stigma of the moonflower.

Owing to the fact that it has not been found possible to hybridize the morning glory without employing the stigma fluid we cannot, with the information at hand, differentiate 1 and 2 so as to determine whether the exemption may be due to one or to the other, or to both combined. The cause of this apparent immunity remains to be determined by experiment.

In the successive repollenations of the original hybrid Bansai, No. 1, no true second generation has occurred; but only a series of progressive first generations; arbitrarily enforced, my working theory, in carrying out these experiments, having been that the type might be fixed and at the same time the vigor of growth increased, by judicious inbreeding as described.

The action of the excretion of the stigma of the moonflower in developing the growth of the pollen should be studied under the microscope. It may be found on further investigation that this stigmal fluid is generic in its action, and that it will also develop the pollen of other genera of plants, so that its possible employment generally in experiments in hybridizing is suggested. Also this work upon the Convolvulaceæ may lead to the search for similar stigma fluids in other monopetalous plants, particularly where hybrids do not occur in the ordinary course of nature.

The X-Ray Spectrometer*

A New Instrument for the Study of the Properties of Crystals

It is now well known that a homogeneous pencil of X-rays is capable of reflection by a crystal provided that the rays are directed upon the crystal at the proper angle.[1] If λ is the wave-length of the X-rays, d the spacing of the crystal planes, and θ the angle which the rays make with the planes, these quantities are connected by the relation $n\lambda = 2d\sin\theta$ [2], where n is an integer.

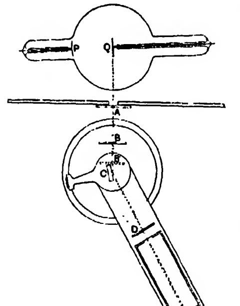
The object of the spectrometer is to determine the value of θ in any given case—that is to say, for a definite set of X-rays and a definite set of crystal planes. The results may be classified as follows: If we use different crystals or different faces of the same crystal, but keep the rays the same, we can compare the spacings of the various sets of planes. In this way we arrive at a knowledge of the relative positions of the atoms in the crystal that is to say, we determine its structure.

If we use the same crystal always, but examine the angle of reflection of different homogeneous X-rays, whether from the same or from different sources, we have the means of comparing the wave-lengths of those rays. We can, in fact, analyze X-radiation in exactly the same way as an ordinary spectrometer analyzes light.

The new instrument resembles the ordinary spectrometer in its general construction. To the collimator corresponds a set of narrow slits limiting a pencil of X-rays, which is directed so as to pass through the axis of the instrument. A crystal takes the place of the diffraction grating, and is mounted on a small revolving table. The crystal face or set of planes which is acting as reflector is made to contain the direction of the axis of the instrument, and the crystal is turned round the axis until the face makes the proper angle with the incident pencil. The reflected ray then enters a cylindrical ionization chamber filled with gas which it ionizes. The chamber takes the place of the ordinary telescope, and the measurement of the ionization current by an electroscope corresponds to observation by eye or by the photographic plate.

In the drawing,[3] which shows the arrangement of the apparatus in plan, Q is the antikathode of the X-ray bulb. The construction of the bulb is a little unusual in that the antikathode is placed perpendicularly to the kathode ray stream; the bulb can therefore be conveniently arranged so that the X-rays leave the antikathode at a grazing angle. The finer the angle which the rays make with the antikathode, the more nearly does the source become, effectively, a "bright" line; and the narrower the line the brighter it becomes, because the "whole illumination" given out in any direction by the spot on the antikathode is independent of the direction. The law followed is not that of the illumination by a surface of uniform luminosity, but rather that of the illumination due to a number of separate sources lying in one plane, each radiating uniformly in all directions. It corresponds to the case described by Rutherford, in which α rays are radiated from a uniform thin sheet of radio-active matter spread upon a plane surface (*Phil. Mag.*, August, 1906). The arrangement is of considerable value; the more nearly is the source a bright line parallel to the slit, the "purer" is the spectrum.

The X-ray bulb is inclosed in a wooden box heavily coated with lead. The object is to protect not merely the observer but also the sensitive apparatus. The slit through which the rays pass is only a few millimeters



long and very narrow, sometimes no more than a tenth of a millimeter wide. Only a small fraction of the pencil that emerges is reflected in the best circumstances, so that it is necessary to screen off all stray radiation with great care; it must be small in comparison with the radiation which is to be measured. Adjustable slits are placed at A where the rays leave the box, and again at B, the second slit being also capable of a movement which brings it close up to the crystal, as at B'. The crystal is shown at C, and a third slit, D, is placed just in front of the ionization chamber.

The ionization chamber is a cylindrical brass chamber 15 centimeters long, and is filled with some heavy gas, so that the ionization current may be as large as possible. Sulphur dioxide is convenient in many cases, but methyl bromide is much better for rays which can excite the bromine X-rays. Such rays are, for example, given off by antikathodes of silver, rhodium, or palladium, the latter two of which have been much used in the determination of crystal structure, because they give off intense homogeneous rays and also stand up well against the bombardment by the kathode stream. The chamber is insulated and maintained at a high potential, which drives any ionization on to an internal electrode. The latter is connected by a fine wire to the gold leaf electroscope (Wilson pattern) within the shield. The connection with the electroscope terminal is made at a point lying on the axis of the spectroscope, so that the ionization chamber and the connecting wire may revolve together about the spectrometer axis without straining the connection. The shielding is made solid and strong; it is necessary that the electrostatic screening should be perfect, and the electroscope must be protected from drafts which may cause changes in temperature.

The gold leaf is illuminated by reflection from a mirror, and viewed through a microscope. A strong X-ray reflection will cause the leaf to move twenty or thirty scale divisions in a second.

The angular positions of the crystal and the ionization chamber are read from the vernier shown. Observations can easily be made to half a minute of arc, and much finer work could certainly be done, if it were required. The actual angle of reflection can be measured with an accuracy higher than can be reached in our knowledge of certain other data used in some of the calculations; for example, the actual weights of the atoms.

Crystals are often very imperfect in construction, consisting rather of a conglomerate of smaller crystals in more or less imperfect alignment. It is interesting to observe that the spectrometer may be used in ways which almost completely overcome the evil effects of the imperfections. In the case of a very perfect crystal like the diamond, the slit at A is not used, but B is set very fine; D is wide open. The crystal is slowly turned by a tangential screw attached to the revolving table, and there is no reflection at all outside very narrow limits. The angle of maximum intensity of reflection can easily be determined to a few seconds of arc. But a crystal of rocksalt cannot be treated in this way. It is best to set A and D fairly fine and not to use B at all. On account of certain most fortunate geometrical considerations, a homogeneous pencil of some divergence issuing from A and reflected at various points on the crystal face is brought to a line focus at D, provided that A and D are at equal distances from the crystal (Proc. Roy. Soc., lxxxviii., p. 433). A perfect crystal would reflect such a pencil only along a certain vertical line on the crystal face; but a poor crystal, like rocksalt, at a number of separate points on the face. Even crystals which are scarcely recognizable as such may be treated by this method.

The higher order of spectra, that is to say, reflections at angles for which n has a large value, three, four, or five, naturally give more accurate values than lower orders, though the intensity diminishes rapidly as n increases. The "resolving power" increases even faster than n, since $d\theta/d\lambda$ is easily seen to be equal to $\tan\theta/\lambda$, which becomes very large as θ approaches the value $\pi/2$. For example, a certain pair of lines emitted by a platinum antikathode are separated by thirty minutes of arc in the first order spectrum reflected by the cleavage face of the diamond, but in the third order spectrum they are two and a half degrees apart.

With a little practice it is quite easy to pick up the reflected X-rays. While the search is being made the slits are opened wide; as soon as the reflection is observed the slits are made narrower, and accurate measurement is then possible. It is a comparatively simple matter to find the angles of reflection of rays of given quality in the various faces or sets of planes of a crystal. The greater difficulty arises in the geometrical interpretation of the results.

* Reproduced from *Nature*.

[1] A summary of the principles on which this experiment is based, and of the progress of its development may be found in *Nature* of July 9th, 1914, p. 404.

[2] See Proc. Camb. Phil. Soc., November 11th, 1912.

[3] From a book to be published by Messrs. G. Bell and Sons.

The Planet Jupiter*

Possible Explanations of Some of Its Phenomena

By Rev Theodore E R. Phillips, M A , F R.A S

Though lacking in those special features which in the popular view invest Mars with such an atmosphere of romance Jupiter nevertheless claims in an equal degree the close attention of telescopic observers. Indeed to the amateur whose optical resources are usually of a modest nature Jupiter affords a far more profitable field for work than Mars whose small disk only now and again presents developments on a sufficiently large scale to be well within the grasp of small apertures. Such a development on Mars has occurred in recent years in the Nepenthes I Moeris, and Thoth region but broadly speaking it may be said that, even in large instruments, the approximately stable features of the smaller and more condensed planet cannot, in the nature of things present constant and unexpected changes such as demand the watchful attention and assiduous work of the observer of Jupiter

As regards physical condition, it has long been recognized that Jupiter has many points of analogy with the sun Its density is the same and it is generally inferred that like the sun it is in a heated and expanded condition and that if not still partially gaseous it is at any rate in a viscous and semi liquid state Many features too of superficial resemblance have been pointed out by various investigators To refer to two of the most striking and obvious instances we may mention (1) The analogy between the spot zones on the sun and the belts of Jupiter and (2) the equatorial acceleration of both bodies.

As regards the first of these it has been suggested by Lau (*Astron. Nachrichten*, Band 195, No 4673) that the reason Jupiter has belts instead of zones of spots is to be found in its rapid rotation The material forced upward from the lower strata of the planet bringing with it a smaller linear velocity than that of the surface, streams eastward and assumes the appearance of elongated streaks If the centers of eruption are sufficiently numerous belts are formed and it is suggested that were the sun's rotation much more rapid than it is the solar surface at spot maximum would also present dark streaks or belts.

In accordance with this theory of belt formation it will be remembered that the great revival of Jupiter's north equatorial belt in 1912-1913 began with the outbreak of a few isolated dark spots which quickly spread round the planet

As regards the second of the analogies above mentioned it will be recalled that the rotation of the sun can be fairly represented by a simple empirical formula the velocity being related to the latitude and diminishing from the equator toward the poles. Now Cassini, in 1690 found that a spot on the equator of Jupiter required about five minutes or so less for a rotation than an object in the southern hemisphere and subsequent observations have established the existence of a rapid equatorial current as a permanent feature of the visible surface of the planet. It is true that the cases of Jupiter and the sun are not quite the same, on the former there is no general increase in the rotation period with increasing latitude but a sudden and abrupt change in the velocity in both hemispheres at about latitude 7 degrees. The equatorial current of Jupiter is therefore like a mighty river sharply bounded by two banks which are usually indicated by the two great equatorial belts[1] Beyond these the arrangement of the currents is unsymmetrical and dissimilar in the two hemispheres but notwithstanding these differences the analogy between the equatorial accelerations of the sun and Jupiter is very striking and it is hardly possible to doubt that the cause in each case is the same.

* From *Knowledge*

Fig 1 July 24th 1913 $\lambda - 55°$ $\lambda_2 = 83$

Fig 4 August 23rd 1914 $\lambda - 78°$ $\lambda_2 = 358°$

Fig 2—August 28th 1913 $\lambda_1 = 60°$ $\lambda_2 = 181°$

Fig 5—August 29th 1914. $\lambda_1 = 336°$ $\lambda_2 = 194°$

Fig. 3 September 12th 1913. $\lambda_1 = 292°$ $\lambda_2 = 200°$

Fig 6.—August 31st, 1914. $\lambda_1 = 270°$ $\lambda_2 = 149°$

The planet Jupiter as seen in an inverting telescope.

It is not intended in this article to discuss in any detail the physics of Jupiter but the analogy to which attention has been drawn between the planet and the sun, suggests certain possible explanations of some of the planet's phenomena

(*a*) It has been found that certain sunspots appear to be vortices, and exhibit a whirling motion It is suggested that many of the Jovian spots are of the same nature and are the results of disturbances whose origins lie at some depth below the superficial layers Kritzinger (see *B A A Journal*, volume xxiv No 9) thinks it probable that in accordance with Emden's theory of the sunspot zones a number of discontinuous surfaces are developed within the planet, and that the edges of these different surfaces at the boundary of the disk produce the belts. The effect of two terrestrial atmospheric layers of different density with one gliding over the other in producing clouds of the cirro-cumulus type is well known and it is hinted that the Jovian spots have an analogous formation Lau also (*Astron Nachrichten* Band 195 No 4673) considers that vortices are formed along the line of contact between the great equatorial current and the slower moving material north and south

It is now very generally held that the Great Red Spot is a vortex That it is not a solid feature of the planet is proved by its extensive wanderings but at least it is sub permanent and has indicated a center of disturbance which has existed certainly for over eighty years as Denning and Kritzinger have independently shown, and probably for over two hundred and fifty years. The idea that the Red Spot is a vortex is well supported by the behavior of the dark material forming the South Tropical Disturbance or Schleier which has been so prominent a feature of the disk during the last thirteen years Six times has the Disturbance which is situated in the same latitude as the Red Spot overtaken the latter and its behavior at such times though still in some respects mysterious is nevertheless instructive Now it has been observed that as the *p* end of the Disturbance approaches the *f* shoulder of the hollow it becomes accelerated but that after its appearance west of the *p* shoulder it is retarded. The same thing is true of the *f* end. This is strongly suggestive that the Red Spot is a center of attraction a vortex which draws into itself the surrounding material. It is, however not certain at what level the Disturbance moves Lau considers that it passes under the white material overlying the Red Spot, and certainly little or no trace of it is seen during its passage across the bay On the other hand, the outline of the Spot itself has sometimes been faintly discerned during conjunction, which suggests that the dark matter is mostly whirled round the periphery of the vortex and passes out on the *p* side. It has been observed that the time occupied in passing from the *f* to the *p* shoulder by the ends of the Disturbance is very decidedly shorter than the time usually required to move over the same distance elsewhere. The vortex theory also explains the formation of the bay or hollow in which the Red Spot lies since the drawing in of matter toward the center at the lower levels must be accompanied by an outward flow at a greater altitude. This latter may very well drive back the material of the south equatorial belt, and consequently give rise to the formation of the well-known bay at its south edge.

(*b*) The equatorial acceleration of Jupiter, like that of the sun, presents an interesting problem. [illegible], in his

[1] The southern [illegible] of [illegible] is usually [illegible] the two components of the [illegible] belt. In the [illegible] hemisphere it is [illegible] at the north edge of the north equatorial belt, though when the belt is [illegible] it [illegible] between the [illegible].

article above referred to speaks of it as a survival from an earlier condition of things, and apparently considers that it has its origin in the falling in of particles possessing a greater angular velocity than the planet itself. Whether the combined momentum of such particles would be sufficient now to produce an appreciable effect may be questioned, but if the masses of the planets and the sun have been in the past much increased by the accretion of meteoric dust particles revolving in direct orbits, the tendency would certainly have been to produce an accelerated superficial equatorial motion. A simple calculation shows that particles revolving close to the sun's surface would perform a revolution in roughly three hours, whereas the sun itself requires for a rotation at least twenty five days. For particles one hundred miles above the present surface of Jupiter and spots on the Jovian equator the corresponding times are 2 hours 57 minutes and 9 hours 50 minutes respectively. The same kind of thing is true of Saturn, and it seems quite possible that we have here at any rate one factor in the production of the equatorial acceleration exhibited by the larger bodies of the solar system.

A point which has attracted the close attention of observers of Jupiter is the variation in the velocity of different parts of the disk. Separate and distinct currents in the surface material of the planet whose latitudinal limits show only small changes have for several years been recognized, but their rates of motion are found to be variable. The drift of spots differs slightly from year to year, and there is reason to suppose that in some instances the variations in velocity are of a periodic nature with minor fluctuations superposed on longer waves of considerable amplitude. Something of this kind seems probable in the cases of the Red Spot[1] and the great equatorial current. The motion of the former has been thoroughly discussed by Denning and by Kritzinger independently, and a period of roughly fifty years has been suggested. Fig. 7 shows the changes in the position of the Red Spot during the last twenty years. It will be seen that since 1901 the longitude has diminished by well over two hundred degrees. The rotation period attained a maximum value of 9 hours 55 minutes 42 seconds ± in 1899, but in the year 1913-1914 (from opposition to opposition) this had become reduced to 9 hours 55 minutes 35 seconds ±.

[1] Some of the irregularities in the motion of the Red Spot have been associated with its conjunctions with the South Tropical Disturbance. During conjunction the motion becomes accelerated.

Fig. 8 shows the changes in the rotation period of the great equatorial current since 1879. The diagram is based on weighted values derived from the results of various observers (cf. papers by A. S. Williams, M. N. volume lxiii, page 14, volume lx, page 465, volume lxxi, page 145; W. F. Denning, M. N. volume lxiii, page 331; Major P. B. Molesworth, M. N. volume lxv, page 691, and so on; B. A. A. Jupiter Section Memoirs, and so on) and shows that the rotation period in 1913 was practically the same as it had been thirty years earlier. The curve exhibits a slight secondary minimum about 1900, which gives it some resemblance to the light curves of variable stars of the β Lyrae type, but observations extending over a much longer period are needed to show whether or not the changes are definitely periodic.

Some reference to the present appearance of the planet may be of interest. A comparison of the drawings of 1913 (see Figs. 1 and 2) with those of the current apparition shows that considerable changes have been in progress and illustrates the characteristics of the surface markings which render Jupiter so attractive an object for telescopic scrutiny. It will be seen from Fig. 5 that the South Tropical Disturbance is now clear of the Red Spot hollow, having just completed its sixth conjunction with that object, and that the Red Spot itself has once more emerged as a well-defined ellipse. To the writer, however, it shows no trace of red, but is neutral gray, presenting a striking contrast to the warm tone of the south equatorial belt. The longitude (ω_2) of the Red Spot at the end of August was about 202 degrees. The South Tropical Disturbance now extends over 110 degrees ± in longitude, the positions (ω_2) determined at Ashtead at the close of August being: Preceding end, 62 degrees +; following end, 173 degrees ±.

It will be seen that marked changes have occurred in the north equatorial, north tropical and north temperate regions of the planet. The brilliant egg-shaped markings which in 1913 formed a belt round the north part of the equatorial zone have become degraded into smaller and less regular white areas, while the dark protuberances are also very unequal in size, shape and distance apart. Observations of thirteen north equatorial markings down to the end of August give a mean rotation period of 9 hours 50 minutes 17.4 seconds, which is a slight increase on the value of last year.

Among recent developments must be mentioned the formation of dark spots on the north component of the north equatorial belt, with white intermediate areas (some of them very bright) in the region between the two components of the belt. Still more interesting is the form assumed by some of the dark markings. They are distinctly arched to the south and inclose small brilliant white spots, the appearance being suggestive of bridges or sometimes links of a chain. At least seven objects are of this character, and an idea of their strange form may be gained from Figs. 4 and 5. Observations of seventeen objects in this region show the rotation period down to the end of August to have been 9 hours 55 minutes 30.6 seconds.

Another striking difference between the appearance of the planet in 1913 and 1914 is furnished by the south equatorial belt. Almost uniformly dark in the former year, it has recently consisted of two widely separated bands with a pale orange region between them.

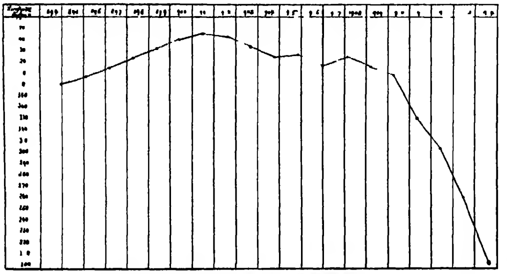


Fig. 7.—Position of red spot at opposition 1894 to 1914.

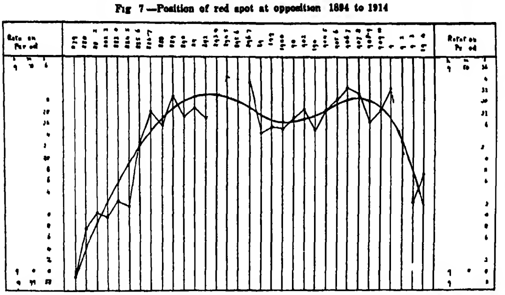


Fig. 8.—Rotation period of equatorial current 1879 to 1914. The value for 1914 is based on observations from May to August only.

The Physiology of Worry*

By Eric D. Forrest, M.D.

With the possible exception of those in the period of happy childhood everyone is at times a victim of worry. In fact, the average individual thinks of and accepts worry much as he thinks of and accepts disagreeable weather conditions—as one of the bitter things of life which must be taken with the sweet. In other words, he regards it as a fact, but does not attempt to analyze it. The wisest thinkers of all times have recognized the condition and many well known writers have expressed their views of its psychology. What has not been sufficiently recognized, however, until very recently, is the importance of worry, not merely in itself as implying the absence of happiness, but as the cause of ills far greater than itself, the cause predisposing to secondary manifestations which would otherwise have been escaped altogether. Having fully comprehended this fact, the next logical step in scientific progression is to determine the exact mechanism by which these disturbances are brought about. Through the conjoined efforts of psychologists and physiologists we are just beginning to reach the true physical basis of this important subject.

The keynote of worry is beyond doubt a disturbance of the mind. It may be defined as the restless consciousness of all encumbrances which we accept under protest. To elaborate this definition, it is the mind's unrest about anything which concerns us, whether it relates to our future, our dear ones, a cause we have espoused, our happiness, our salvation, our means of support, our position in life, our health, our fate or our success in general. It does not consist solely in our interest in all these things. It is rather a disquietude arising from a feeling of helplessness before the various chances and claims of life. The popular opinion seems to be that the mental condition is one of depression, possibly because the physical manifestations are chiefly depressive in nature. The fact cannot be too strongly emphasized, however, that the primary mental condition is one of overactivity, and moreover overactivity along lines of fixed ideas.

Without taking up individually the phases of worry brought about by the various specific causes, the physical manifestations of worry in general may be said to be—depression of respiration, sighing, disturbances in rate and force of heart beat, vasomotor changes, disturbances in secretion, pallor, cold extremities, relaxation and decreased motility of the alimentary tract, dilatation of the pupil, loss of weight, insomnia and general physical exhaustion. These disturbances may vary in their prominence and may appear as groups of symptoms characterizing well known diseases. Thus worry is sometimes an important agent in the production of diabetes, gout, exophthalmic goiter and chronic heart disease.

Inasmuch as worry is primarily a disease of the mind, and since every portion of the body is intimately connected with every other part by a net-work of nervous tissue of great complexity, we naturally seek for the causes of those manifestations first of all in the nervous system.

In every individual at a given time there is a limited amount of potential energy stored up in the cells of the brain. This function seems to rest in the chromatin granules of the nerve cells, and it has been shown repeatedly that a liberation of nervous energy, whether in response to a psychic or sensory stimulus, results in a physiological degeneration of the chromatin granules and consequently of the cells themselves. Obviously a prolonged discharge of nervous energy diminishes by so much the amount left in the brain cells. Furthermore, stimuli of sufficient number, intensity or duration may cause exhaustion and death.

* From the *Medical Record*.

Exactly this phenomenon occurs in the state of worry, except that the degree of fatigue rarely reaches the fatal extreme. Through mental overactivity, and the corresponding chromatolysis in cells concerned in mental processes, discharges of nervous energy to all parts of the body take place through the cerebrospinal axis and the sympathetic system. Whether the action of a given structure is augmented or inhibited, of course, depends upon its inervation. One of the most constant effects of such long-continued discharges, however, is the production of a certain amount of tonic contraction of most of the voluntary muscles, which, if at all noticeable to the individual, he describes as a slight increase of body tension.

A physiological degeneration of nerve cells is normally offset by a slow regeneration, occurring during the periods of physical and mental repose. In worry, because of the fact that the catabolic process is at first more rapid than the anabolic, gradually diminishing as the lower limit is approached, and because continued mental activity gives rise to insomina, a period soon arrives when the expenditure of vital force in the shape of obvious work done has reached a point where the regenerative process, slow as it is, is just about able to offset the breaking down. The phenomena expressing the depletion of the vital force are termed "physical exhaustion." This is to be distinguished from "shock," wherein the stimuli lead to no obvious work done, and the expenditure of energy is extremely rapid.

The sympathetic system, probably because of its intimate relation to vegetative functions, seems to be susceptible to a much slighter degree of stimulation than are the nerves of the cerebrospinal axis. When, in the course of events, therefore, the latter nerves are no longer able to respond adequately to the stimuli arising from the mental activity, the sympathetic is apparently capable of carrying on functions even greater than those which it is normally called upon to serve.

Bearing these facts in mind, we see a possible explanation of some of the various physical phenomena. For instance, stimulation of the sympathetic, with a decreased activity of the motor oculi nerve, causes dilatation of the pupil. Depression of the vagus, phrenic, and intercostal nerves decreases the breath rate. The sigh, so often observed in worried individuals, is simply a very deep inspiration which occasionally takes place to compensate for what would otherwise be insufficient oxygenation of the blood. Through depression of the vagus and the simultaneous stimulation of the sympathetic, the heart action frequently becomes rapid and weak. The vasomotor changes are chiefly constriction of the peripheral vessels, due to stimulation of the sympathetic nerves. In this connection the reciprocal action of the veins of the omentum is brought into play, these vessels often becoming enormously distended with blood. Constriction of peripheral vessels, combined with enfeeblement of the circulation, accounts for the palor and cold extremities so often seen. The secretions are often decreased in amount through narrowing of the vessels supplying the glandular tissues. The extremely dry mouth and lips which probably everyone has observed when be has been worried is a familiar example of this. The stimulation of the sympathetic may, on the other hand, be so severe as to bring about increased secretion in spite of the diminished blood supply, as is evidenced by the so-called "cold sweat." Inhibition of motility of the stomach and intestines appears to be brought about by stimulation of the splanchnic nerves, again a part of the sympathetic system.

In addition to the nervous system as a means of coordinating the various parts of the body there is a method which makes use of chemical processes. In some of the lower organisms this latter method is the only means of unification and is developed to a relatively high degree. The difference between the two methods is essentially one of time, the nervous system being obviously the more rapid by far. These chemical substances have been given the names "hormones" and "colyones," according to whether their functions are those of augmentation or inhibition. They are all included under the general heading of "internal secretions."

Internal secretions are substances produced by gland cells from raw materials furnished by the blood, which are afterward passed back to the blood or lymph stream, to assist in regulating the general nutrition of the economy or to serve some more specific purpose of equal importance to the organism. They differ from the better known or external secretions in that in all typical cases the latter are poured out upon epithelial surfaces which communicate with the exterior, while the internal secretions are discharged upon the closed endothelial surfaces of the blood and lymph vessels. With their development in any organism, a susceptibility to their action must arise in certain of its structures. In the broadest sense, internal secretions must be looked upon as something common to all active tissues, but the best known and probably the most important ones are produced in the liver, pancreas, thyroid, adrenals, pituitary body, and probably the ovary, testis, thymus, kidney, and spleen. From the standpoint of their importance in worry, those derived from the pancreas, pituitary body, thyroid, and adrenal glands seem to occupy first place according to the theories evolved as the result of the most recent investigations.

For experimental corroboration of our theories we are compelled to make use of animals, such as the dog and cat, because of the fact that chemicophysiological experiments such as these necessitate extensive and dangerous surgical procedures. Therein lies a great difficulty. Although the animals are readily obtainable we are never sure that a condition of worry analogous to that found in the human organism is simulated. These animals are, however, visibly susceptible to agencies producing fear, and by modifying the results obtained while they are in this state, in accordance with the intimate relation known to exist between fear and worry, many of the theories regarding the influence of the internal secretions may be substantiated.

The function of the internal secretion of the pancreas seems to be that of assisting in the combustion of glycogen, the product of starchy materials ingested as food, in the muscles. Muscular energy is derived from this oxidation, but in order for it to take place two ferments, one produced in the muscle itself, and the other the internal secretion of the pancreas, must be present in quantities of a certain definite proportion. If the balance is destroyed it cannot take place, and the sugar accumulating in the blood to more than the normal percentage appears in the urine.

Two theories as to the part which worry plays in diabetes deserve consideration. The first is to the effect that the pancreatic ferment is decreased, owing to constriction of the blood-vessels in the glandular tissues. The other is that by stimulation of the sympathetic nerves the secretion is increased. The latter theory seems to have the more supporters, but in either case diabetes results from an overturning of the balance between the muscle ferment and the product of the islands of Langerhans.

Worry also seems to increase the internal secretion of the pituitary body. Recent experiments show conclusively that an excess of pituitrin in the blood, without other complications, produces a marked rise of blood pressure and a slowing and strengthening of the heart beat. It appears to slow the heart by acting upon the peripheral endings of the vagus, the nerve whose function it is to bring about that phenomenon normally. An interesting feature of its effect upon vasomotion is that while most of the peripheral vessels are constricted the arterioles of the kidneys are dilated, allowing an abundant supply of blood to those organs. At the same time, pituitrin exerts a direct stimulating effect upon the secreting cells of the uriniferous tubules. These three factors increased blood supply of the kidneys, increased blood pressure, and hyperactivity of the secreting cells—may well account for the marked diuresis so often observed in worried individuals.

Occasionally, after long-continued worry or extreme fright, the symptom complex—known as exophthalmic goiter—is observed. It probably does not affect an individual unless a previously enlarged or disturbed thyroid gland is present. However this may be, the disease is undoubtedly associated with a hypersecretion by this gland. Since it is supplied by the sympathetic it seems reasonable to infer that this oversecretion is brought about by the stimulation of its controlling nerves. An excess of this substance in the blood, in contrast to the effects of pituitrin, dilates peripheral arterioles, probably by a direct action on the muscle in the vessel walls, bringing about a visible flushing of the skin. It also appears to have an antagonistic effect upon the substances which influence the nutrition of the body, as is evidenced by the rapid loss in weight in this disease and the excretion of large quantities of nitrogen, carbon dioxide, and water in the urine. That it has a definite action upon the nervous system is shown by the tremor usually present. The pulse is at the same time rapid and throbbing in character.

The effects of the internal secretions thus far considered must not be regarded as constant manifestations of this emotion. In fact, the cases are relatively rare in which diabetes and exophthalmic goiter do occur. Inasmuch as we have come to ascribe to all body tissues powers of secretion, is it not entirely reasonable to presume that secretory disturbances in one organ may be offset or held in check in a majority of cases by products of other structures? We know this to be an almost universal principle in animal function, exemplified by the opposed actions of the vagus and sympathetic in the control of the heart. Denied this liberty, we can only, at present, make use of the vague term "individual susceptibility" in explaining this seeming inconsistency.

There is an internal secretion, however, that of the adrenal glands, which appears to be always associated with the most constant effects of worry. Adrenalin, or epinephrin, as it is called, is an excellent example of the manner in which most of the internal secretions and the nervous system interact and supplement each other, for it has been shown that it does not act upon any organ or tissue which has no sympathetic or autonomic nerve supply. In fact, its point of attack appears to be the end arborization of the nerve fiber where it joins the muscle or tissue. The presence of physiological quantities of adrenalin in the body seems to be a necessary condition for the normal functioning of the entire autonomic system.

The secretion of adrenalin is controlled by the sympathetic and is increased in worry. We cannot say that its presence in the blood in abnormal quantities is responsible altogether for the phenomena which are dependent upon the autonomic nerves, for we have seen how the increased stimulation of the sympathetic, by means of mental overactivity, can bring about these things. It does, however, magnify the action of the sympathetic and is capable of maintaining this action alone, for a considerable period of time after the sympathetic stimulation has been removed. The latter phenomenon is accounted for by the fact that there is an autogenous continuance of most of the internal secretions, including adrenalin. In other words, these substances, coming in contact with the tissues which originally produced them, tend to stimulate still further production. After a time, however, even this mode of adrenalin derivation ceases, for the blood gradually gives up its epinephrin by aeration in the lungs.

After the foregoing discussion it can readily be seen that many features of worry have not been considered. This condition, together with its allied emotions, constitutes an enormous field for further scientific investigation. In view of the rapid improvement which modern laboratory technique is undergoing, and the increased interest with which experimentalists are viewing psychophysiological matters, there is a great probability that within the next few years many of the remaining doubtful points will be satisfactorily explained.

Storing Heat

According to a story in *Power* a state dinner was to be given in a castle in Germany in which there was no heating system, but as this mediæval condition could not be tolerated in modern times, for the dinner was a function of recent occurrence, the engineers were asked to heat the building for the occasion; but it was specified that no portion of the heating system was to be visible in the room. The result was accomplished by means of stored heat. For a number of days previous to the dinner, the floor of the dining room was covered with steam pipes and these pipes were kept hot by means of a temporary boiler. The day before the dinner all the pipes were removed and the stored heat in the walls maintained the room in a perfectly comfortable condition for a number of days, although the outside temperature was well below the freezing point.

Organic Matter in the Soil

In the annual report of the Bureau of Soils of the U. S. Agricultural Department is the following statement in regard to the importance of the organic matter contained in soils:

"Organic matter is essential to make a soil of what would otherwise be pulverized and more or less hydrolized rock, and while there are some soils that contain small quantities of organic matter capable of growing crops, on the whole the quantity of this material in average soils is considerable. The average organic content of soils amounts to approximately fifty tons per acre, and yet the nature of this material has been but little understood. It has been believed for many years that it consisted chiefly of some such body as humic acid, differing perhaps in different soils, but having the same general properties. One prominent service which these investigations have rendered agriculture has been to show the non-existence of humic acid and its hypothetical relatives and to show instead the existence of many compounds with many relationships.

"This line of research has been especially profitable during the year just past, and the number of compounds isolated and identified has been increased to more than forty. Some of these compounds contain only carbon and hydrogen; some carbon, hydrogen, and oxygen; some carbon, hydrogen, oxygen, and nitrogen; others contain phosphorus or sulphur. Isolation in a pure condition of these organic constituents of soils has made possible the correct interpretation of the changes that organic matter undergoes in soils. The compounds found are recognized as representing decomposition products of fats, carbohydrates, proteins, and other classes of natural compounds, and a great deal of light is shed thereby on the processes of humus formation and transformation in the soil. These researches into the nature and properties of soil organic matter have shown conclusively that the soil investigator must take into consideration the presence of organic compounds in the soil."

Peculiarities of Earthworms*

Compound Forms That Are Hard to Explain

By Prof. Dr. E. Korschelt

It is not so very unusual to find double or multiple forms among animals, such compound structures in particular not being especially exceptional among segmented worms. Some years ago Prof. Dr. E. Korschelt described in the "Zoological Year Book of 1904" earthworms of double and triple form, peculiarities of structure which had been gained mainly by experiment. He now writes an interesting article in the *Umschau* upon an earthworm with a double rear end, the origin of which is difficult to explain. This earthworm, one of the species *Helodrilus longus*, was found out of doors and was still in an immature state. In crawling the front had measured to the spot where the rear end forked 7.5 centimeters, the right branch of the rear end 4 3 centimeters, the left branch 4 centimeters (Fig 1).

Apart from the fact that the worm was somewhat clumsier in its movements than one of normal form, its way of moving varied but little from the ordinary. When placed upon loose soil it soon bored its way into the earth and quickly disappeared. When crawling the contractile waves passed simultaneously from the front end to both rear ends, which worked normally during the crawling. The transmission of irritation was as usual from the front end to the rear ends and *vice versa*, a point that was easily settled by touching the end of the head or of the tails. From this may be deduced the continuity of the main nervous system, as well as of the vascular system and of the intestinal canal. The arrangement of the rows of bristles and the way they fit into each other is best seen from Fig 2. At the forking there is some irregularity in the arrangement of the segments which overlap suitably to the dividing of the body (Figs. 1 and 2) In Fig 2 is shown by dots the respective positions and course of the rows of bristles from the ventral side upward.

It is not possible to determine from the condition and manner of action described whether this anomalous structure has existed from the beginning, that is, whether it is the result of the development of the embryo, or whether the double form has arisen from an injury If the worm had been injured when young so that a new rear end grew out from the wounded spot, or if the tail end had been completely lost and, on account of a suitable conformation of the surface of the wound, two rear ends grew out of this, there could follow under the circumstances, a far reaching rearrangement of the segments and it would hardly be possible to determine the difference of this form from a double structure arising from embryonic development This has been proved by a fairly large number of double-tailed worms produced by Dr. Korschelt by means of experiments. He says further:

"During some earlier exhaustive researches observations were made as to the length of an earthworm's life, which led to the surprising conclusion that these worms can live ten years and more The writer is now able to give more exact information as to the conditions of their life It is entirely accidental that these observed worms were ones upon which transplantations had been made. It was not intended at the time to determine the length of life but merely to watch the changes which might arise from the operation made upon the worms. For this purpose they were subjected to observations covering a long period of time In addition, the selection of the species of earthworm, *Lumbricidæ*, was also accidental and was brought about by the kind of operations made upon them, just as this, on the other hand, influenced the life of the respective worm. The life of the *Eisenia* (*Allolobophora*) *fœtida* was, for instance, a relatively brief one, being from 3½ to 4½ years. This brevity of life can be accounted for in this way; either the unions of parts were such as not to have much vitality, or external circumstances affected the length of the respective experiment and shortened the period of observation. This latter explanation holds true for the single specimen of *Lumbricus terrestris* (*L. Herculeus*) which was kept for a considerable length of time and which lived to be 5½ to 6 years old. Experiments were made on a larger scale with the *Helodrilus longus* (*Allolobophora*) [*Lumbricus*] *terrestris*, and somewhat by chance a large number of specimens of this species of earthworms was preserved for experiment, and for these worms the carrying out of the experiment permitted as a matter of course a longer lease of life for the united portions. The respective specimens lived for 6½, 7½, and 10½ years."

It should be remembered in connection with the ages given that these were worms which were kept in confinement under rather limited conditions of space. The question could be raised whether these conditions are not more likely to produce a prolongation rather than a curtailment of life, as the imprisoned worms lived in comparative inaction and their forces were only exerted to a small degree. It is difficult or indeed hardly possible to answer this question with certainty so long as we know nothing positive on this point concerning worms that lead a natural life, especially as we do not know whether they pass through longer or shorter periods of inaction. In general, the earthworms are probably not much affected by unfavorable conditions of temperature and weather, as it is possible for them to go down to considerable depths in the ground. How far they really do this cannot be determined with certainty from the observations so far made It seems that earthworms go down

Fig. 1.—Rain worm with double rear end.

Fig. 2.—Arrangement of bristles at point of separation. Evident irregularities of the segments.

2 to 2.5 meters in the ground Their burrowing can be easily traced down to 2 meters, so that those which are long enough lived to do this seem to be well protected against the cold. On the other hand, frozen earthworms have been found in the ground at about a depth of 0.5 meter. The question here is whether such worms could not awaken to new life if the cold were not too severe and too long continued.

There have been repeated accounts of earthworms on and in ice and snow Experiments in freezing them have also been made which show that earthworms, and also other Oligochæte, can bear relatively low temperatures without permanent injury. Dr. Korschelt made experiments with various Oligochæte which were exposed for a considerable time in glasses of water to the almost complete freezing of the water. The experiments were up to 24 hours in length at a temperature of 5 deg. Cent, and lower, and the worms began to move again after the water gradually thawed out. They were absolutely vigorous and were observed for weeks further Taken altogether, earthworms seem to have less power of resistance, although in the experiments made on them they always bore temperatures down to 5 deg. Cent., for though they seemed to be frozen stiff they always revived to fresh life.

"It is safe to deduce from these experiments and observations which have been continued up to the present time," continues Dr. Korschelt in discussing his experiments, reports on which he has published in various scientific journals, "that the worms under natural conditions can bear a fairly low temperature, go through a certain condition of freezing and then wake up to a new life. Earthworms which are dug up in winter after a period of frost hardly move at all and seem frozen, but in the temperature of a room they soon become more animated and crawl about. It is most probable that the earthworm goes through a period of torpor something like hibernation at a considerable depth in the ground At any rate, just as such early observers as Morren, Hoffmeister, and Hensen stated, they are found in the enlarged ends of pipes, rolled up in a ball either singly or in nests."

According to observations made upon imprisoned earthworms by our author, they can also pass through periods of torpor of another kind, namely, periods which protect them from droughty conditions. When moisture is lacking for them they withdraw into the depths of the ground as far as possible, and they are found rolled up close together in an underground hollow which has fairly firm walls, smooth on the inner side and apparently held together by a secretion of the worm. If the torpidity lasts a good while, the worms lose decidedly in volume, become shorter and show retrogression, especially of the genital region. This may be explained by the loss of water and the insufficient amount of nourishment taken during this 'dry sleep'" If this condition does not last too long and the worms become moist again, they then come out of the earth-capsule and under normal conditions resume their former mode of life.

"These observations show a certain agreement with those communicated by several other investigators but traced to other causes," says Dr. Korschelt. "Thus W. Harms remarks when making experiments in transplantation, that the earthworms lying in a round hollow would tie themselves up into a 'tight knot' after they had stopped taking nourishment while still moist and when sufficient nourishment was present The worms, consequently, had fallen into a kind of 'heat torpor,' in which if it lasted too long, certain retrogressions of their organisms would appear similar to those described above in 'dry sleep,' and this could lead to considerable reduction in size, as a shortening of the body. Somewhat different are the statements made by Vejdovsky, according to which his observations concerning the appearance of torpidity in earthworms both out of doors and in imprisonment were not to be traced to conditions of temperature and weather, but rather to exhaustion after continued sexual activity. That those earthworms which had burrowed down into round holes in the ground had also, as in the above mentioned cases, suffered a reduction of the genitalia as well as one of the bulk of the body seems very probable from Vejdovsky's statement As the holes in the ground have a fairly firm wall, Vejdovsky speaks directly of an 'encysting,' and compares it with the encysting of another Oligochæte, the *Aelsoma*, which both he and Beddard had observed. This latter, a water worm, when unfavorable conditions appear secretes around itself a layered envelope in which it lies curled up. It thus passes through the unfavorable weather, and when conditions are once more suitable it comes out of the envelope. The author himself has had occasion to produce by suitable measures the encysting of this worm in a thickly populated Aeolsoma culture and thus to confirm the observations made by the two above-named investigators."

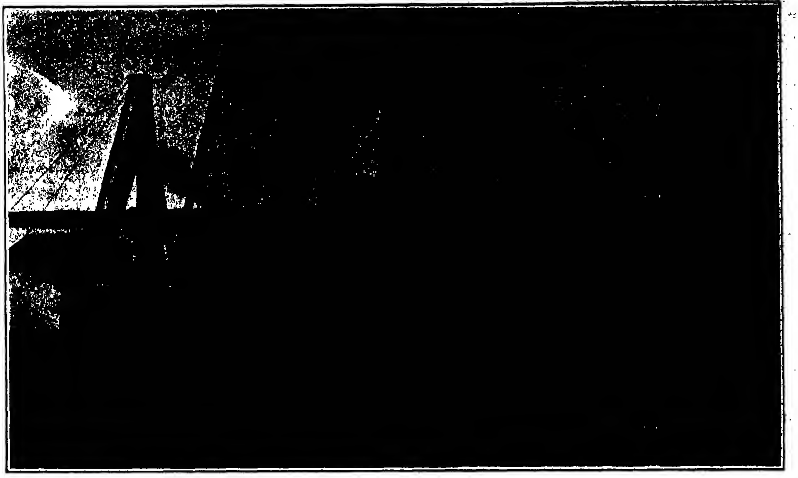
The exceedingly scanty number of observations concerning the torpidity and encysting of the Oligochæte has just been increased by an observation made by Mrazek on the *Claparèdella*, another worm which lives in the water These worms are accustomed to live at spots which are exposed to drying up. When there is danger of this dryness they creep under the fallen leaves in the deeper layers of mud, roll themselves up here and secrete around themselves a glutinous covering In Mrazek's opinion this action may also have another meaning, namely, that processes of separation in the organism of the worm may take place within this capsule.

The object of these communications was to compare the prevailing conditions among earthworms with those existing among the other Oligochæte, and by the appearance of undoubted periods of torpidity among the latter to strengthen the conclusion reached concerning the former This does not settle the point how far these conditions of existence affect the question of the age attained by earthworms, but even if certain reductions have to be made in the figures of 6, 8 and 10 years obtained for the ages by direct observation, the figures that remain far exceed all expectations.

* Translated from *Umschau*.

A Russian Embargo on Woods

The Forest Service of the Department of Agriculture is authority for the statement that the Russian government has placed an embargo on all kinds of lumber, to prevent its exportation; walnut lumber, including Circassian walnut, much prized by American furniture makers, is specifically mentioned.



Showing cofferdams, molds, and reinforcing bars of the piers of the Pennsylvania viaduct.

Concrete Viaducts on the Pennsylvania Railroad

Replacing Insecure Wooden Trestles With a Substantial Road Bed

By Day Allen Willey

When the Pennsylvania Railroad Company built its line from Philadelphia to Washington the use of concrete for viaducts and bridges was unknown to the engineer. When the surveyors went over the proposed route between Havre de Grace, on the south of the Susquehanna, and Washington they found it necessary to make soundings of three inlets to the Chesapeake named the Bush, Gunpowder, and Back rivers, and it was found that the beds of these inlets consisted of liquid mud to a depth of over fifty feet. The plans for bridging these inlets provided for wooden trestles, the supports consisting of wooden piles driven into the mud formation which formed the bottom of the inlets and strengthened by a double row of braces fastened diagonally between each pair of piles.

The structure was so weak owing to the uncertainty of the foundation that parts of its frequently gave trouble, delaying train service until the defects could be remedied. The engineering department has always realized the necessity for permanent viaducts over the Bush and Gunpowder rivers having firm foundations, and it was decided to replace the frame structures with reinforced concrete viaducts.

The right of way was ample, but it was desired to put in the new bridges with as few new curves as possible, and these conditions were met by throwing the new bridge alignment on a slight angle with the old. The center line for the bridges was carefully laid out and measured on the ice in the winter, making careful corrections for temperatures, and using a standardized tape.

The old bridges were used as base lines and the new line was tied in at numerous points. At each bridge site a small concrete pier was erected on the shore for locating the center line, with three wooden blocks inserted for the tripod legs, and the point was located on this pier, and a foresight was carefully placed in the water. Thus, practically all the points were located using a foresight. Permanent backsights were established, but were only used when the foresight was obscured by smoke, hazy weather, etc.

The river mud was of the consistency of silt and was removed by pumping. The piling for the foundations was driven by steam hammers, attempting to reach the desired penetration with each pile. In some cases, however, it was impossible to obtain the penetration necessary, probably owing to the piles striking a conglomerate. Whenever it was impossible to obtain the desired penetration two extra rows of piles were driven for the pier, and the footings were spread. Wooden cofferdams were used, constructed of 6 by 10 sheet piling, which were driven with a small rapid action steam hammer. The pumps which excavated the mud were located on a small barge, and no difficulty was experienced in pumping the material 2,800 feet through 12-inch pipes. The piles were cut off so as not to extend more than 2 feet into the footing, provided the desired penetration was obtained. Where the first pile in the pier brought up above this point the remainder of the piles were sawed off accordingly, so little cutting off was necessary after driving.

To make a solid and firm bed for the concrete foundation a large wooden funnel was built, with an opening so small that the gravel would not run out fast enough to stir up the mud. This funnel was loaded with gravel and slowly moved around over the cofferdam. This process was continued until a layer one foot thick was placed, and then it was ready for the concrete.

A concrete plant was built on barges at each river. A large hopper divided into two parts was kept supplied with sand and stone by a clam shell bucket, unloading from barges alongside. The cement was stored on the main barge, and in the first plant built, at Bush River, the cement was carried to the mixer by laborers. In the other plant the cement was carried forward by an endless chain conveyer.

The concrete was raised in an elevator to the top of the tower and poured through the piping into the forms by gravity. The collapsible forms for the connecting arches were made of 3½ by 3½ by ¼ inch angles in five parts. The upper ones were bent to the radius of 4 feet 3 inches. Quarter-inch boiler plate was bolted to these angles, and the angles were bolted to the wooden pier lagging, and aided considerably in holding the pier forms in proper alignment.

The economy of steel truss supports is apparent, there being about 290 spans of the same length in the two structures. These trusses were set up on jacks and upright timbers with wedges between, resting on horizontal transverse timbers, which in turn were supported on the pedestals of the piers.

Jack screws were used to bring the trusses to the proper height, also to let down the trusses when striking. The trusses were lowered directly onto a barge, and towed to the next pier by a gasoline tugboat. The forms for one span were frequently collapsed, hauled to a new position, and jacked up into place in three hours.

Expansion joints were provided at every third pier. These were made by layers of cheap felt paper, making a thickness of one inch. The footing is 10 feet wide, 33 feet long and 6 feet thick.

The piers and footings are provided with steel reinforcing to take care of unequal strains or settlements. The footings have 1-inch square twisted steel bars as follows: 2 longitudinal bars 33 feet long, just outside the vertical pier bars; 10 transverse bars on about 3 feet centers, with an extra one between the two bars at the center of the piers.

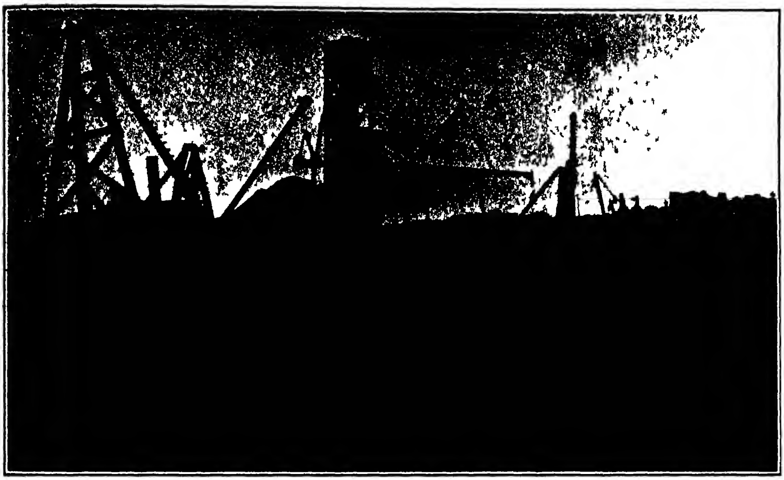
The tops of the floor slabs have a drainage slope from all directions to the 4-inch drain pipe placed at the center of the slab, so water can flow directly into the river.

An idea of the extent of this construction, which was let out in one contract, is given by the following quantities of material needed: Combined length of bridges, 7,714 feet; total number of piles, 13,777; number of yards excavated (wet) 97,000; yards of concrete masonry, 76,400; reinforcing steel rods, about 8,850 tons.

There are 186 duplicate regular piers, two abutment piers, two rest piers, and one center pier, all of reinforced concrete, with pile foundations. The footings, 6 feet deep, are made of concrete mixed nominally in the ratio of 1:2:4, and an additional 20 per cent of cement to compensate for wash due to the deposition of the concrete under water. Bottom dumping buckets were used in the cofferdams before the latter were pumped out.

Work was commenced on the viaducts March 15th, 1912, and the entire structure was completed September 15th, 1913. Considering the difficulties encountered in connection with the pier work, the construction was completed in a remarkably brief period, the average working force being only 400.

To test the strength of the viaducts a train of 80 loaded freight cars, each car weighing 60 tons and drawn by one of the most powerful locomotives in service, weighing over 100 tons, was hauled over the structure at a speed of 25 miles an hour without causing the slightest vibration.



Concrete mixing and distributing plant on one of the Pennsylvania viaducts

Actual Instances of Dual Personalities—II*

Cases in Real Life That Rival the Wildest Fiction

By Edward Tyson Reichert, M.D., Sc.D., Professor of Physiology in the University of Pennsylvania

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2035, Page 3, January 2, 1915

The history of Mary Reynolds was reported by Dr. S. Weir Mitchell to the College of Physicians of this city in 1888. The subject was a very impressionable girl. A nervous shock resulted in the development of multiple personalities which existed over a period of years, her normal personality, as in the cases of the fictitious Dorothy and the real Miss Beauchamp, being restored by hypnosis.

Miss Reynolds's family moved from England to the wilds of western Pennsylvania during the early part of the eighteenth century. She is said to have possessed an excellent mental capacity and to have enjoyed fair opportunities to acquire knowledge. Besides the domestic arts and social attainments she had improved her mind by reading and conversation. Her memory was capacious and well stocked with ideas. She was sedate and reserved and tended to melancholy. When eighteen years of age she had hysterical fits and after one of these attacks was blind and deaf for six weeks. About three months later, after having almost wholly recovered her normal health, she fell into a profound sleep which lasted about twenty hours, upon awaking from which memory had completely fled and she was to all intents and purposes a being for the first time ushered into the world. Her parents, brothers, sisters, and friends were not recognized; the scenes to which she was accustomed—the house, hills, field, forest, vales and streams—were new. She began to learn, but always when in this new personality she looked upon those she had once known as strangers and enemies among whom she was by some remarkable and unaccountable means transplanted, though from where she had not the remotest idea. She learned to read and write, but her handwriting was not the same as that of her primary state.

Instead of being melancholy she was cheerful to extremity, buoyant and sociable. Formerly taciturn and retiring, she was now merry and jocose, extravagantly fond of company, and enamored of nature.

Six weeks after the appearance of her second personality she fell into a protracted sleep, from which she awoke in her primary state, recognizing the members of her family, remembering what she had planned as though but yesterday. She was absolutely without memory of the events of existence of her second personality and was greatly surprised at the change that occurred in nature over night.

Remaining in her primary state for a few weeks she again fell into a sleep from which she awoke in her secondary personality, now beginning life where she had left it weeks ago when she re-entered the life of her primary self, having now only the knowledge of her secondary state. Her vivacity, wit and humor were now so great as to make her company very much sought, but her love of playing tricks upon others often led to much trouble. Alternations in personality went on for fifteen or sixteen years, the secondary personality tending to remain for increasingly longer periods; when she assumed the second personality, continually existing in this state for the remaining twenty-five years of her life without the least knowledge of her other self beyond what had been told her.

Another case in some respects similar to that of Miss Reynolds and known as Félida X. was studied by Dr. Azam and has become world renowned. Félida came under Dr. Azam's observation when fifteen years of age. She had had many hysterical and other troubles which led to her becoming a timid, serious, grave and melancholy individual who was burdened with anxiety and pain. Appearing to faint away for a few moments she would awake, having an entirely different personality. Her pain, anxiety, and other mental and physical infirmities had vanished and she was gay, vivacious and coquettish and morally perverted. She remembered the incidences of her normal life, as did Sally of the life of Miss Beauchamp, but when in her primary state, like Miss Beauchamp and Miss Reynolds, she had no knowledge of her secondary state. These personalities alternated with great frequency, but the primary state lasted for shorter and shorter periods and was ultimately crowded out, as it were, by the secondary state, as in the case of Miss Reynolds, which thereafter constituted her constant personality.

It is probable that in the cases of Miss Reynolds and Félida the personality which at first was regarded as the secondary personality was in reality the primary personality or normal state, [illegible] that the personality that was ultimately established was in reality not the secondary but the primary.

In these cases of dual personality the nature of the change in the individual's moral character may differ very widely. We have seen in the instance of Dr. Jekyll and Mr. Hyde a form of moral monstrosity that is manifested in an inherent intellect[illegible] and a demoniacal pleasure in the infliction of torture on others, a form of immorality that arouses hate, fear and loathing. In the cases of Becky, Sally, Mary Reynolds and Félida there were forms of moral perversion that led to the annoyance of themselves or others, or of such a kind as to engender sympathy. The most pathetic among these instances of marked moral alteration was that of a young woman, recently a patient in this city, who in her natural state was the personification of all that is attractive, lovely and sublime in young womanhood, and who at times upon awaking from a deep sleep would have an entirely different personality, with manifestations of moral monstrosity that vied in vileness with those of the denizens of the tenderloin.

In many cases the secondary personality appears but once and sooner or later gives place to the normal. An interesting instance belonging to this category was reported by Dr. Osborne. The subject was a man of middle age, in admirable health, very fond of his family and not known to have any eccentricities, morbid tendencies or bad habits. For years he had resided in a town near this city and by strict application to his business, which was that of a tinsmith and plumber, had been successful and accumulated some means. One dull and gloomy Sunday in November he mysteriously disappeared. He had remained in the house mainly engaged in reading and playing with his younger children until 4 o'clock. Arising from a couch upon which he had been reclining and reading, he said that he was going out for a short walk and a little fresh air. Leisurely, quietly and apparently perfectly normal, he stepped outside of the door to disappear as mysteriously as though the earth had swallowed him.

Two years later in a tin shop in one of the southern towns where a number of men were engaged at work, one of the men suddenly dropped his work and press-

* A lecture delivered at the University of Pennsylvania, December 1914.

ting his hands to his head in a dazed way exclaimed "My God where am I? How did I come here? This is not my shop What does it mean?" At first the men were disposed to laugh and jest at the man who for several months had been so reserved and sober and who had worked so quietly by their side but of whose history they knew nothing Seeing his changed expression his face wet with perspiration and his nervous twitchings and hearing his piteous appeals they became startled and called him by a name that was strange to him yet the one he had given them Trembling with suppressed emotion he made his way to the proprietor and with some difficulty made the proprietor understand his true condition and the story of his northern home family and prosperous business which as it seemed to him he had left but the afternoon before Under the assumed name he had been known and paid but the entire period from the time he left home until the present was a complete blank After ascertaining the whereabouts of his family he joined them and from last accounts was living the life of his normal self

A variable number of different personalities may develop in a given individual the person living as many different lives each being partly or wholly ignorant of the existence of the others Thus a man by the name of Monks a son of wealthy people who lived in London lived four different lives mingling in four different classes of society and having four different sets of friends As a conscientious clerk he was quiet retiring deferential cared little for the society of women did not smoke and was extremely exemplary in his habits As a professional bicycle rider he was loud voiced boastful swaggering profane a smoker and a drinker As a society man he was a fashion plate in his attire of graceful ease and extremely popular with the ladies four of whom in different parts of London he was engaged to marry As a burglar he was most skillful and daring and it was only after years that shrewd detectives ran him down and not knowing of his peculiar mental state had him committed to prison as a common criminal

A case of a man having six personalities was reported by Bourru and Burot In the first personality he was initiative violent arrogant rude disrespectful anti religious embarrassed in speech and with limited though precise memory In the second personality he was reserved gentle in speech orderly respectful without religious opinion and his speech was easy and pronunciation clear and he had little memory of the past In the third personality his state was very much like the second but his memory was limited entirely to the third state In the fourth personality he was timid and well mannered and his intelligence was obtuse his memory confused and his language incorrect and childish In the fifth personality his mental state reverted to the period when he was fourteen years of age He had the timidity language and attitude of a child and was without memory of any of the incidents of his life subsequent to this time In the sixth personality he was a proper young man a soldier of the marine corps and his memory embraced his entire life excepting the period known as his fourth state

In a young girl as many as ten personalities were developed in twenty months and in one of them she reversed everything—to her white was black heat was cold etc and even her writing was reversed

Among all of these remarkable cases of dual personality none is on the whole so interesting and so instructive as that of the Rev Thomas C Hanna which was carefully studied by Drs Sidis and Goodhart ("Multiple Personality" 1905) and no summary however brief would be adequate without at least some reference to this extraordinary record The differences in the personal traits the complete loss of memory in the secondary state the gradual childlike acquisition of knowledge the childlike wonderment of what was seen and heard and the ultimate recognition of the existence of two personalities with their separate lives and their final blending form one of the most absorbing stories in psycho physiological literature

The Rev Mr Hanna was born in 1872 and had an exceptionally good family history and all the advantages of an excellent education and was a good scholar He entered the Manual Training School of this city and his high scholarship gained for him admission as a free student to the Architectural School of this university During his stay with us his sense of religious conviction became so awakened that he gave up his studies for those of theology and in order to prepare himself for the practical duties of the ministry he took up missionary work

He had an earnest ardent sympathetic and impulsive nature was well balanced and possessed a strong will combined with perfect self control We find him at twenty five years of age the pastor of a church at Plantsville Conn

At 7 o'clock one Thursday evening when attempting to alight from a carriage his foot caught in a lap robe and he fell head foremost, striking his head, and when picked up a few moments later life seemed almost extinct. In this state he remained for two hours, then began to move looked around in a bewildered way, rose from the bed and in a dazed manner attempted to push aside one of the physicians. His three attendants, believing him to be delirious, seized him and attempted to force him back to bed, but Mr Hanna's strength, while ordinarily excellent, now seemed herculean, and his opponents were readily worsted Finally he was overcome and securely bound with straps for fear of his injuring himself or others. While now having the physical strength of an exceptionally robust man his mind was a blank as void as though he had just been ushered into the world He saw smelt, tasted and touched but these senses conveyed absolutely no meaning excepting as to mere light and darkness and color Objects space and time were without intelligent perception There was no perspective sense everything irrespective of distance appeared close to his eyes giving him the impression of one great picture An object seen through the window appeared as near as his outstretched hand and he would not have had any hesitancy in attempting to grasp the moon

Sensations of hunger gave rise to great distress, but without arousing the least knowledge of the reason Food placed in his mouth did not excite any sense of its use He made no attempt to either masticate or swallow it and in order to feed him it was necessary to force food back into the pharnyx to cause reflex or involuntary swallowing movements

Bodily movements alone at first attracted his attention and he learned in time to distinguish between movements of his own body and those of other people and things He gazed at moving objects with the wonderment of the young infant and after he had learned to associate movements with life he thought all moving objects living things the swaying of the branches of a tree appearing to him movements of living creatures and the horse and carriage a single living object

He heard conversation or noises as he termed them and in time recognized that by their means people could understand each other and although he had not the least idea of the meaning of a single word he thought he could learn to communicate with others by repeating the noises he had heard Hence he would again and again repeat in his mind these sounds and then repeat aloud words and sentences he had committed to memory but he was surprised to find that he was not understood and for a time he became discouraged Not knowing the meaning of his utterances his speech was of course utterly unintelligible It was not until the lapse of two days that he had learned the real meaning of a single word

By this time he was able to recognize time by the difference between daylight and lamplight and by the recurrence of the three daily meals His education may now be said to have been fairly started He began to understand speak read and learn to walk

Owing to his mental faculties having been highly developed and to his inherent capacity for rapidly acquiring knowledge he learned with amazing rapidity even to the attainment of accomplishments that were unknown in his normal life Thus he learned in a few hours to play the banjo an instrument with which he had had absolutely no experience

For nearly two months he remained in this mentally childlike state gradually but with extraordinary rapidity acquiring the elementary knowledge common to early childhood having absolutely no knowledge of his existence before the accident or of his actual relations to the people about him and developing during this period an entirely distinct personality as different from his normal as the personalities of two people differ His memory was so keen during and after this period that upon his ultimate recovery he was able to give a minute account of his experiences and thus unfold a remarkable history of incidents such as presumably are attendant upon the education of the infant and very young child

The period of second personality lasted for seven weeks and was ended by his falling asleep and awaking as the Rev Mr Hanna he now having absolutely no remembrance of what had transpired since the moment of the accident He thought that the accident had occurred the evening previous and when told that it was seven weeks ago he thought the speaker jesting and the story a huge joke

He had been in New York for some time but he failed to recognize his surroundings and the people who had been in constant attendance for weeks past were absolute strangers excepting his brother the only one he had known in his normal state

In the midst of the conversation he suddenly exclaimed "What a funny taste in my mouth you must have been feeding me on tobacco" Before going to sleep he had smoked a cigarette but not having used tobacco for many years and not having any knowledge of the events of the previous evening he could not in any way account for the taste. When asked how he felt, he said "I feel just like Rip Van Winkle." After remaining in his primary state for three-quarters of an hour he fell asleep awaking in his second personality his mental life beginning where it had ceased upon falling to sleep the night before, he not having a vestige of knowledge of what had transpired between the two periods of sleep

From this time on there followed frequent alternations of the primary and secondary personalities, the transition from one to the other occurring without obvious cause and with increasingly greater frequency The alternations were for a time wholly unknown to Mr Hanna, excepting in so far as he was informed by others and owing to the very different memories of the two states more or less serious embarrassments were caused

With the passing of time the frequent alternation of personalities, the gradual acquirement of knowledge during the periods of his second personality, and the increasing information received from those about him of his mental dual existence, there came a moment when he clearly recognized the existence and differences of two personalities or mental lives Struggles of the two for the possession of the body occurred at which times Mr Hanna would be in a dazed state and in neither one nor the other personality What went on in Mr Hanna's mind was quite accurately remembered by him and is well set forth in a statement made by Mr Hanna to Drs Sidis and Goodhart

Mr Hanna stated that while lying upon a lounge in one of these dazed conditions he had engaged in one of the most intense struggles he had ever experienced The two personalities the primary and secondary states rose simultaneously and confronted each other Each of them was the I still they differed from each other The memories seemed to be those of two different persons yet he recognized that both were his He could not choose one because it differed from the other nor could the two be joined The struggle produced great perplexity and perturbation He felt that both were his yet it seemed impossible to unify them One could not be abandoned because both came up constantly before him as though exclaiming We are one though different It seemed as if each said to the other Thou art a mortal foe and yet thou art bone of my bone and flesh of my flesh Each it seemed had for a time tried to crush or suppress the other The question in his mind was which of the two lives he should reject and then the struggle was not so much to choose one as to forget the other both persisting in his consciousness as though each memory was stronger than his will Each memory seemed to be within the same physical being as if there were two bodies alike like twins that had lived entirely different lives or like twins of the same body with tastes faculties and natures very similar The time came when he realised that he must take one or the other personality The decision was difficult and the mental struggle great but he finally decided to adopt both because of the fear and anxiety that the struggle would be repeated again and again and that the mental agony of these recurrences would be too great to endure And so in time the two personalities differing so much were fused into one healthy normal mental individual—into one Ego or I the present Mr Hanna

The passing of the hour permits of but an additional word We are creatures not only of to-day but also of yesterday In the secondary personality of Mr Hanna we found evidence as development proceeded of the presence of his primary state and in the latter state of his secondary state Time and again one state would force itself into the other each for the time struggling for mastery finally one letting go as it were the better or the worse state becoming for the time the Rev Mr Hanna

In each of us the Ego or I is not a unity but a duality a blending of primary and secondary selves of conscious and subconscious mental lives of mental processes that, broadly speaking express the human and animal sides of our natures As one or the other may for a time dominate so are our personalities modified As the speaker is uttering sentence after sentence he is conscious of the occupation of the mind with the phrases of the moment, but beneath this consciousness there lies a most potential mental life or background which while seemingly latent or wholly beyond the field of consciousness or introspection is extremely active a life that embraces memories of past experience of self and countless ancestral individuals. It contains the fundamental structural material or sense-images or memories from which all our thoughts are built and moulded

Our physical peculiarities are heritages that go back into the dim past, and they are expressions of causes that had origin beginning in time unknown, our mental lives are heritages that likewise have come to us

through a countless line of ancestors for thousands of centuries. The impress of our progenitors upon our mental lives is not less than upon our physical lives. Just as each of us has an Ego that is a blended duality that is readily separable into two different selves, so has each of us a dual immortality—an immortality of the soul that is ours alone and an immortality of the mind and flesh that is transmitted to our offspring and which passes from generation to generation. The emotions and thoughts of thousands of preceding generations and the acts of the lives of the barbarians, savages, semi-educated, educated and cultured individuals who through the course of time have ultimately given us birth echo and re-echo in our beings. Their personalities, like their bodies, have been born and reborn in their children and children's children to be born and reborn for better or worse in ourselves and our offspring.

Some Features of Photo-Chemistry*

Are They the Results of Electrical Phenomena

By H H McHenry

The subject of photo-chemistry is one about which comparatively little is known. While the applications to ordinary photography are well understood the theory that leads to the chemical action of light is far from being perfectly comprehended.

The photo-chemical process has two phases. The production of a compound is one phase, such as the production of chlorine knall-gas. The other is decomposition, such as the decomposition of hydrogen phosphide with separation of phosphorus. This latter phase is by far the more common. The chemical action of sunlight such as that shown in the bleaching process, the production of green colors in plants, and the well-known action of light used for blue-printing, have been known for centuries. Only recent investigations however have taught us that numerous compounds are sensitive to light, and convinced us that here we are dealing with a mutual action between ether vibrations and chemical forces. By experiment it is found that the chemical action of light takes place only in special cases, as it is held that illumination can exert an influence on the reaction velocity of a system which is in the process of change, or on a system in the state of equilibrium which is in chemical repose.

Before discussing the theory of the other vibrations, it might be well to cite a few features of ordinary photography. The modern chemical method employed in development rests on what is known as the "latent light-action of the silver salts." A gelatine film impregnated with silver bromide is first illuminated and then treated with reducing agents. The silver haloid in the plate is then reduced to silver most quickly. At the illuminated spots this reduction results in the formation of free halogen, but the nature of the reduction product is not known in all cases. On the illuminated spots of the plate small particles of metallic silver are deposited by reduction, their density increasing with the intensity of light, but always in such small quantities that no visible change occurs in the substance of the plate. When the plate is put into the developer those invisible silver particles act as nuclei for the precipitation of silver, just as small crystals bring about crystallization in a super saturated solution. The denser the silver particles at any spot the denser will be the deposit of silver during development.

A valuable aid to photography was furnished in a discovery made by Vogel in 1878. He found that photographic plates may be made more sensitive by intermixture with slight traces of organic coloring substances. Also the plates are usually especially sensitive for kinds of light absorbed by particular coloring substances. Thus plates may be prepared sensitive to yellow, blue or red, or any colored light. This phenomenon is called optical sensitation. So far no theoretical explanation has been given for it.

As light is thought to be a phenomenon occasioned by ether vibrations, the theoretical consideration of its chemical effects must lie with those vibrations. When ether vibrations traverse a material system, they occasion two different results. First, they raise the temperature of the system, their energy being partly converted into heat. Secondly, they occasion chemical changes, occurring at the expense of some of the energy of vibration. The first phenomenon is known as the absorption of light, the second as the photo-chemical absorption of light. Gases, liquids, and solids all respond to ether vibrations, such as the explosive mixture of hydrogen and chlorine, chlorine water which gives up oxygen under the influence of light, and white phosphorus which changes to the red modification, in light, or cinnabar which turns black. While photo-chemical action may be produced by any type of ray, it depends on the wave-length of the light used, like ordinary absorption.

A set of empirical laws of photo-chemical action, compiled by Eder, serves as an aid to understand the chemical action of light-rays. They are: (1) Light of every wave-length is capable of photo-chemical action. (2) Only those rays are effective which are absorbed by the system, so that the chemical action of light is closely associated with optical absorption, although the converse is not true. (3) According to the nature of the substance absorbing light every kind of light may act in an oxidizing or reducing way. The red light has an oxidizing effect, and violet light a reducing effect on the metals. (4) Not only the absorption of light rays by the illuminated substance itself plays an important part, but also the absorption of light by a foreign substance mixed with the principal substance, for the sensitiveness can be stimulated for these rays which are absorbed by the admixed substance. (5) A substance sensitive to light admixed with the main substance and which unites with one of the products resulting from photo-chemical action (as oxygen, bromine or iodine) tends to accelerate the reaction velocity to such an extent that reversal is impossible. This may be regarded as a consequence from the law of mass action.

As stated above these laws can only be regarded as empirical. There are some exceptions, notably to (3). Red light exerts a reducing effect in the case of the latent light-action of the silver salts, while violet oxidizes organic compounds, especially colorless ones. These laws were ascertained by means of instruments known as actinometers, which measure the intensity of the chemically active rays. The idea of actinometers is a most important one. All pieces of apparatus which are designed to measure this intensity, and which collectively depend upon the observed changes which are experienced by substances sensitive to light when under the influence of ether vibrations, are called actinometers. The data obtained from actinometers of all kinds must be considered as having a purely individual nature. They give only a *relative* measurement of the intensity, for if the same kind of light is used the nature and reaction velocity of the chemical process occasioned in each case will vary according to the behavior of the system which is subjected to the action of light. Also when the light used consists of rays of different wave-length, the data of the same actinometer will by no means be proportional to the intensity of light, as the action of light varies greatly according to its wave-length.

It might be well here to consider a few types of actinometers. The eye can be considered an actinometer because apparently, its sensitiveness to ether vibrations depends upon certain photo-chemical processes which are thereby occasioned. However, the results of visual photometric measurement are not parallel with those obtained by actinometers, and neither results are parallel to those obtained by thermometric measurements. The latter is usually regarded as an absolute measure of radiation. It would perhaps be more correct to regard the diminution of free energy which is unknown associated with the change of radiant energy into heat as the measure of the intensity of light.

A simple form of actinometer is that known as the chlorine knall-gas actinometer. It depends on a discovery of Gay-Lussac and Thenard in 1809, who found that when strong light acted on the combining of chlorine and hydrogen the velocity increased rapidly to the point of explosion, and, when weak light acted, it progressed slowly and steadily. The method consists in measuring the diminution of a volume of chlorine knall-gas (standing over water, and maintained at constant pressure and volume) as a result of the formation of hydrochloric acid, which is absorbed by the water. This actinometer was constructed by Draper in 1843 and, later, improved by Bunsen and Roscoe.

These two men discovered the silver-chloride actinometer, in which the time required to darken a photographic paper until a definite "normal" shade is reached is taken as a measure of light-intensity.

Another interesting actinometer is the electro-chemical actinometer. Two silver electrodes, which have been chlorinized or iodized, are dipped into a dilute solution of sulphuric acid. Electromotive force will be established between the electrodes, and as long as one of them is illuminated the current will flow in the solution from the unlighted to the lighted pole. The strength of the current is read by means of a sensitive galvanometer, and this serves to determine the intensity of the light. Results obtained by this actinometer agree approximately with those obtained in photometric ways. This actinometer was constructed by Becquerel in 1839.

Attention may now be turned to the work performed by chemically active light. One would expect the light to be absorbed to a greater degree when it occasions or accelerates a chemical process than when such is not the case. Bunsen and Roscoe found that when light passed through a layer of chlorine knall gas it was much more weakened in its chemical activity than when it passed through chlorine alone. In both cases the light is weakened by absorption by the chlorine, the absorption by the hydrogen can be neglected. But in the first instance absorption is purely due to optical activity and therefore the loss of energy reappears in the heat developed. In the second case however an additional fraction of light-energy is consumed in performing chemical work which thus occasions a stronger absorption. This phenomenon is called photo-chemical extinction.

A word may be said as to the speed of chemical light-action. Bunsen and Roscoe found that light usually acts very slowly at first and only attains its full activity after a lapse of time. This is called photo-chemical induction. Pringsheim succeeded in showing that this phenomenon is due to the formation of intermediate compounds. As chlorine knall gas is more sensitive to light when moist than when dry it seems probable that hydrogen and chlorine do not unite directly to form the acid but that a series of intermediate compounds is first formed. Also a slight preliminary exposure of a photographic plate renders it more sensitive and an under exposed plate is strengthened by a subsequent exposure.

The physical laws which chemically active photographic rays obey are of peculiar interest. They are reflected, refracted and polarized like other rays, their intensity diminishing as the reciprocal of the square of the distance from the point of origin. Research work has shown that when light of the same kind is used the photo-chemical action depends solely on the product of the intensity and the duration of exposure. It has also been proved beyond doubt that the time required for the development of a normal color on sensitive paper is proportional to the number of light-waves which strike the paper per second.

One important difference between photo-chemical reaction and ordinary reactions is that the velocity in the former increases but little in a rise of temperature, while that of the latter increases enormously. We are led to believe that light action should not be regarded as a direct loosening of the atoms in a molecule such as that effected by heating but rather the primary effect must be some action on the luminiferous ether and suggests ionization.

Now what is the cause of these light-vibrations? The latest authorities maintain that light-vibrations are produced by electric agitations, and that in the chemical action of light we deal with phenomena not far removed from the formation and decomposition of compounds under the influence of the galvanic current. That chemical equilibrium is affected by illumination follows from the change in the thermodynamic potential of components by illumination as may be more clearly deduced from the electro-magnetic theory of light. It has been proved that electrification and magnetism alter the thermodynamic potential and the motion of light-waves is according to the most advanced theories, that of rapidly alternating electric fields. From these conclusions we may assume at least until further knowledge of the subject is gained, that the ultimate cause of the photo-chemical action of light lies in electric phenomena.

* Reproduced from *Knowledge*.

A New Recreation Region

The Forest Service of the Department of Agriculture directs attention to a little known region that offers unusual attractions to sportsmen and others who enjoy an outing in the open. It says the Uinta Mountains of Utah, included within the Wasatch, Uinta and Ashley national forests, should become a favorite recreation region because of the many small lakes within depressions scooped out by glacial drifts. Seventy such lakes can be counted from Reid's Peak, and one particular township, thirty six miles square, contains more than a hundred.

Protecting Silvered Mirrors by Copper Plating

The fact that the silvering of mirrors is subject to deterioration from various causes has given rise to no little trouble in this branch of the industry but this has been entirely overcome by the new French process invented by Declère, Gresy and Pascalis for producing a protecting coat of electrolytic copper upon the silvering of mirrors especially as regards mirrors of large size. Architects often hesitate to put large mirrors in new buildings on account of the frequent deterioration by dampness and the emanations from fresh walls. Another source of trouble comes from saline air on the sea coast which cause damage to mirrors in these regions. For a long time a good method of protection has been sought for not only against dampness but also from such gases in the air as sulphurous anhydride, sulphuretted hydrogen and others. Direct use of varnish should be avoided because of the presence of bitumen and other substances, and moreover varnishes have been found insufficient protection and are not durable. The chemist Liebig's method was to cover the silver plating with an electrolytic coat of metal but this very rational plan has up to the present time been limited to small opticians and surgeon's mirrors because of the difficulty of applying it on a large scale. The present idea refers to mirrors which have been coated with silver by a deposit of that metal on the glass from a suitable bath, and the object is to extend the Liebig process to looking glasses of all sizes such as are so widely used in shops and public buildings.

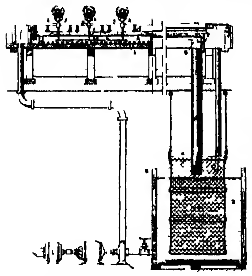
Up to the present time it has only been possible to connect the electrolytic current by contacts placed at the edges of the mirrors to be protected, which plan had the serious inconvenience of producing deposits thicker at the edges than in the center of the mirror by reason of the great electrical resistance offered to the passage of the current by the thin silver coating. The center of the glass thus received a very slight covering of copper.

The great difficulty has been to multiply the metal contacts direct on the surface of the silvered glass so that the density of current should be uniformly distributed. By the direct application of the contact on the surface of the mirrors there was the risk of doing considerable damage to the delicate silver plating, the thickness of which is well known to be infinitesimal (about 0.0005 millimeter).

The Declère, Gresy and Pascalis process does away with these inconveniences. The most interesting and characteristic part of the process is the system of the rheophores which distribute the current by the aid of hundreds of contacts which by simple devices are brought into delicate contact with a silvered mirror and distribute the current equally over the silvered glass.

Because of their multiplicity each contact possesses a very limited field of action and as the contact is made by hundreds of points distributed over the glass only a small amperage is delivered at any one place, thus avoiding the violent action while dividing the useful effect of this current in a very uniform manner without loss. The deposit of copper thus obtained is perfectly continuous and homogeneous and does not admit dampness or any other cause of alteration.

The negative rheophore is formed by a sort of comb made up of brass wire teeth, each of which makes a contact with the silvered surface, and forms a center of distribution. The expenditure of current is very small, and the rods of the "rheophore" are sheathed except at their extremity in such a way that the electrolytic deposit is laid equally over the surface of the glass.



Sectional views of Gresy coppering apparatus.

A, electrolysis vat; *B*, vat containing the reserve solution; *C*, centrifugal pump; *D*, *E*, outlets fitted with cocks; *F*, emptying pipe with valve *G*; *a*, cotton filter; *b*, pegs to hold plates *c*; brass rods forming the teeth of the comb; *f*, nut holding the teeth of the back of the comb formed by bars *g* and *h*; *n*, *o*, *p*, arrangement for raising the teeth of the comb; *q*, anodes; *t*, dynamo generating the electrolysis current; *u*, motor.

By this new process it is possible to manipulate as many pieces of glass as the vat will contain, so that one can obtain the maximum of production at the same time with the smallest space. The system of anodes used in the process is extremely simple, inexpensive and rapid, and offers the advantage of covering only the glass to be treated.

The use of the under reservoir permits the electrolytic vat to be emptied as soon as the operation is over and the mirrors are washed and left to dry in the vat. The handling of the glass during the process is thus avoided, with the economy of not having to provide a special washing vat.

The consumption of electrolytic liquid is also much reduced by the present construction of the apparatus and the active circulation of the bath in the vat by means of a centrifugal pump results a continuous filtering out of the impurities in the bath, thus leaving no trace of them on the copper deposit. The cost of the current and of the electrolytic liquid is strictly proportionate to the area of the plates to be coppered.

The general operation of the apparatus is simple and regular and essentially practical, and the average workman can execute the copper plating perfectly after a few explications and on glass of any dimensions.

Description of the Plant.—The apparatus consists of two tanks, the top one of which *A* is that used for the electrolysis. The other tank *B*, generally placed underground, contains the electrolytic solution which a centrifugal pump *C* forces continually to the inlet *D* where suitable guide pieces direct the current toward the surface to be treated. The solution passes through vat *A* and returns by an outlet *E* to the vat *B* where all impurities are removed by passing through the filter *a*. By means of a large pipe *F* with a valve *G* all the liquid may be sent back to vat *B* when the operation is finished. The wooden electrolytic vat *A* is fitted at the bottom with pegs or cleats *b* to support the plates *c*.

The rheophore is formed by a comb, the teeth of which consist of brass rods *e* attached to the bar *h* by nuts *f* and passing easily through the bar *g*. The lower end of the teeth *e* are tipped with tin, a soft metal which is not liable to damage the silvering. The teeth are moreover surrounded except at the bottom end by an insulator generally consisting of a covering of paraffine. The lower bar *g* is fitted at each end with a flexible cable *k* by which it receives the current from copper

General view of coppering plant

conductors *c* which connect with the negative pole of the source of electricity. The cable *k* is joined to the conductor *c* by the clamp *m*. The bar *g* is rigidly attached to bar *A* and the gears *o* operated by the hand wheel *n* and shaft *p* raise or lower the bar *n*, thus regulating the contact of the teeth *e* with the surfaces that are to be copper plated. The rheophore may be lifted out of the vat as shown in Fig. 1 to facilitate the manipulation of the plates.

The anodes are formed by copper strips *q*, each strip being fixed to a wooden bar as shown in Figs. 2 and 3. A dynamo *t* generates the necessary current and gives about five volts and thirty amperes per square meter of glass to be coppered. The pump *c* and dynamo *t* are generally placed on the same shaft with the motor *u*.

Rangefinders

Of the many instruments designed by the engineer for the more accurate conduct of naval warfare none is of greater importance than the rangefinder. In the days of Nelson no such device was necessary. To come to grips ships of war were obliged to approach so near to one another that there was rarely any doubt about accurately laying the guns, and any error could be promptly corrected. In modern warfare conditions are very different, and a naval engagement of the first order of importance may take place with the units of the opposing fleets separated by miles of ocean. But the engagement, says the London *Daily Telegraph*, can only come to a satisfactory conclusion if the rangefinding

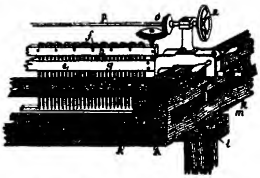


Diagram showing details of apparatus used.

has been accurate and the range within the limits of the guns for an adequate period. With projectiles costing some hundreds of pounds apiece, and the possibility of disaster if one of these misses its mark, it is clear that for rangefinding to-day the unaided human eye is no longer of the value it was in the days before the coming of steam and the ironclad.

Since the eighties therefore much ingenuity has been directed toward obtaining an instrument which at a glance, would indicate correctly the distance of any object within range of vision. One of the latest types being an anti aeroplane instrument. This is so mounted that the base of the instrument swings in a vertical plane and the eyepiece is situated in the line of the trunnion, thus enabling the rangetaker to make observations with comfort upon objects at practically all altitudes. The mountings of such rangefinders are specially designed to enable a rapidly moving object to be kept under continuous observation.

A single observer rangefinder may be regarded as consisting of two telescopes mounted in a common frame with the two objectives situated one at each end of the frame and with the eyepieces at the center, suitable reflectors being provided at the objectives to direct the beams of light along the frame toward the eyepieces and the whole arrangement being such that the combined telescopes may be simultaneously directed on the same target. The rangefinder itself forms the base of a triangle having at its vertex the object, the range of which is determined by measuring the parallax, i. e., the angle subtended by the base of the instrument at the object. Two beams of light from the distant object are received by reflectors at the ends of the base and are transmitted through two objectives toward the center of the instrument, where another pair of reflectors placed one over the other reflect the beams outward through the eyepiece. Each objective forms an image of the distant object in the focal plane of the eyepiece and the observer therefore sees in the field of view two images which, depending upon the type of instrument used, may overlap one another or be separated by a fine separating line.

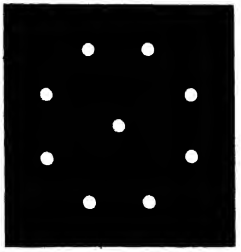
Optical or mechanical devices are adopted in rangefinders of this class for altering the course of one or other of the beams of light within the instrument, so as to bring the two partial images into correct coincidence or alignment, and a scale is provided for indicating the distance of the object, the scale or its index being moved by the gear used for bringing the images into alignment.

Plant Only Certified Potatoes

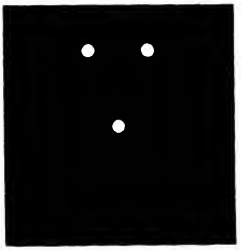
In some sections of the country potatoes are infected by a powdery scab and as a result these districts are quarantined by the Department of Agriculture, which has issued a warning to farmers and others that in procuring seed potatoes to use only such as come in sacks bearing the white label of the Potato Inspection Service. Table potatoes for the general market are shipped in bulk and the car alone bears a blue certification tag, so it is not desirable to buy ordinary eating potatoes for seed purposes. Some dealers are said to be selling eating potatoes for seed purposes, and while they are not violating any law, those who buy this kind of seed are liable to find they have introduced a dangerous disease and are liable to quarantine. The white seed certificates relate only to freedom from powdery scab and not to the quality of the potatoes, still those in certified seed sacks are apt to be more carefully selected than the average stock.

Guide Lights on Aviation Fields*

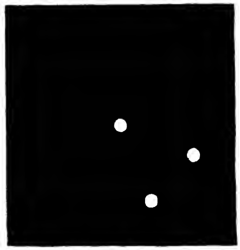
The aviation field at Johannisthal, Germany, is to have an underground lighting system which will indicate for the nocturnal aviator the best place for landing and the direction of the wind. The lights are inclosed in iron boxes, which are covered with round panes of very thick glass and are sunk in the ground to their tops. Eight such boxes are arranged at equal distances in a circle the center of which is marked by a ninth box. Each box contains a red and a white electric light, and the current, conveyed by underground cables can be switched into either light by hand or by an automatic device operated by the wind. The direction of the wind, which by day is shown by a canvas imitation of an aeroplane landing against the wind, is correspondingly indicated at night by three white lights. Two of these lights, marking consecutive vertices of the octagon, represent the wings of the aeroplane, while the third, at the center represents the tail. The other five lights are red.



All lights are white in a dead calm



Arrangement of lights for a north wind



Arrangement of lights for a southeast wind

Of the eight principal points of the compass that can be indicated in this way that one is shown which most nearly represents the actual direction of the wind. The landing is made against the wind by steering the aeroplane over the central light and midway between the other two white lights. In a dead calm all of the lights are white and the landing can be made in any direction. In the accompanying illustrations as in maps the top is north, the right side east, etc. The white lights are represented by white circles, the red lights by shaded circles.

The Function of the Earth in Radio-Telegraphy†

A lecture on the above subject was delivered on Friday evening November 13th by Dr. J. A. Fleming to the members of the Wireless Society of London at the Institution of Electrical Engineers. Dr. Fleming said that the present period of enforced inactivity for all loyal radio telegraphists except those engaged at the seat of war offered an opportunity to reconsider some of the purely scientific questions involved in the art. He proposed therefore to discuss the function of the earth in radio-telegraphy. Apart from the disputed question whether the aerial wires should preferably be earthed at the base or connected to an insulated balancing capacity, it was well known that the nature of the soil or surface between the transmitting and receiving stations had a great effect on the signal strength. This effect depended much upon the wave length. Thus Dr. L. W. Austin had shown that the ground to the north and northeast of Newport Rhode Island U. S. A. exercised a powerful absorption on radio-telegraphic waves of about 1,000 meters wave-length. Experiments made between Brant Rock wireless station and the United States cruiser "Birmingham," lying at Newport showed that whereas electric waves of 3 750 meters wave length suffered little or no absorption in traveling over the forty-five miles other than that due to the normal space decrease of energy, waves 1 000 meters in length lost 95 per cent of their signaling energy in passing over the same district.

Dr. Fleming first gave a brief mathematical discussion showing the manner in which the gradual penetration of an alternating current into a conductor can be explained. It is well known that high frequency electric currents are confined to a thin skin or layer of the surface of metallic wires. In the case of copper this skin has a thickness of about 0.25 millimeter for currents of a frequency of one million. In the case of iron the skin for the same frequency is about 0 02 millimeter.

An elegant experiment was shown by Dr. Fleming with his cymometer to illustrate this surface flow of high frequency currents. An oscillation circuit was arranged in which high frequency currents were generated and these were detected by placing alongside a cymometer having a Neon vacuum tube as a detector of secondary oscillations in its circuit. In the primary oscillation circuit were inserted successively small spirals of copper brass iron and galvanized iron all having the same size and same number of turns. The oscillations in the cymometer circuit were indicated by the brilliant glow of the Neon tube. When the iron spiral was inserted the Neon tube did not glow because of the damping of the oscillations caused by the energy absorbed to magnetize the iron. The galvanized iron spiral behaved however just like a copper or brass spiral because the oscillations did not penetrate through the thin layer or skin of zinc into the iron. If however this zinc was oxidized or broken then the iron core exerted its effect in damping the oscillations.

Dr. Fleming then explained that when a radio-telegraphic wave passes over the earth it penetrates to some extent into it, and also loses amplitude owing to the absorption of wave energy by the soil. The depth of penetration or depth in which the forces attenuate to ϵ or to 0 368 of their surface value and the horizontal attenuation or distance in which the surface values decrease to the same fraction of their original value can be calculated as shown by Dr. Zenneck when the values of the soil conductivity soil dielectric constant and frequency are known. Thus taking the generally accepted values for sea water for waves 1 000 feet in wave length the penetration into the sea is at most about one meter. In the ordinary dry soil it may be 100 or several hundred meters. There is a certain soil conductivity and wave-length which gives the maximum attenuation of the wave over a given distance.

The calculation of the depth of penetration and attenuation of the wave with distance can be made when this soil conductivity and dielectric constant is known. Recent researches have shown however that the conductivity of imperfect insulators for alternating currents is much greater than for direct currents. Dr. Fleming referred to researches by himself and Mr. Dyke for proof of this fact. Lately he said Mr. Bairsto had continued this work in his laboratory for currents of extra high frequency of one or more million and found their dielectrics had a maximum conductivity for a certain high frequency. The inference from this was that the earth was an incomparably better conductor for the high frequency curves used in radio-telegraphy than for ordinary low frequency or steady currents. Dr. Fleming then went on to consider the propagation of an electric wave over the earth's surface and pointed out that Sommerfeld had shown that when a Hertzian oscillator had one half connected to the earth there would not only be space waves through the dielectric (air and earth) but a surface wave along the surface which would consist in longitudinal electric currents propagated as a wave motion along the surface. Dr. Fleming pointed out that this surface wave might be the explanation of the well known facts that signals from long distance wireless telegraph stations can be picked up and detected without any high receiving wire merely by connecting one end of the receiver to the earth and the other to any insulated mass of metal in the interior it may be, of a house.

Passing then to the consideration of the diffraction of long electric waves round the earth Dr. Fleming gave a brief account of the state of the theories advanced by Poincaré, Nicholson, Macdonald and Rybczynski. These agreed that the amplitude of an electric wave sent out horizontally from any point on the earth's surface diminished according to an exponential function of the distance and wave length. The last named analyst had shown that this function was of the form ϵ $\sqrt[3]{\lambda}$ where r is the distance of the sending and receiving stations and λ is the wave-length. Actual observations by Austin over distances up to 1 000 miles had led to an empirical formula differing only in that $\sqrt{\lambda}$ appears instead of $\sqrt[3]{\lambda}$.

The bulk of the evidence so far collected as to long distance transmission showed however that true diffraction of space waves or even the surface waves could not contribute more than a moderate fraction perhaps not 20 per cent to the total observed result. The chief part of the effect for distances of 3 000 to 4 000 miles must be contributed by space waves which had reached the receiving station indirectly that is after reflection or refraction at the surfaces of layers of high altitude ionised atmospheric gases in the manner explained by Heaviside and by Eccles.

The great variations in signal strength taking place from day to day in long-distance wireless intercourse proved that this must be the case.

In conclusion Dr. Fleming exhibited a chart showing the variation in the strength of the signals received at University College London from the Eiffel Tower station in Paris at 11 A. M. each day during last July prior to the outbreak of war. The sudden falling off on certain days was remarkable. Dr. Fleming said that the further examination of the cause of these variations was one of the chief objects of the British Association Radio-telegraphic Committee which was appointed at Dundee in consequence of a suggestion made by him and that as soon as the present calamitous world war came to an end it was hoped these researches might be resumed.

Concrete Wine Cellars

In the region of Champagne in France the wine in bottles is stored in vaulted cellars which are hollowed deep down in the chalk strata but it is observed that cellars of this kind are not always of the healthiest for infiltrations of water are likely to occur. This not only has a bad effect on the quality of the wine but may give rise to a cave-in of the roof. Reinforced concrete comes in here to furnish a solid vaulting that does not depend on natural conditions and recent structures were put in with a comparatively light vaulting and straight walls with concrete flooring as well. The result is a watertight construction which can be kept perfectly clean. An example is seen in one of the cellars at Epernay where the reinforced concrete shell vault follows the outlines of the chalk cut cellar but there is left an air space all around of 4 to 8 inches thick and an air circulation is produced by making suitable openings to the outside. The inside of the vault or cellar has no connection with the exterior part, and is thus kept dry and in the best condition.

Preserving the Forests

Great areas of valuable timberlands are destroyed by fire every year and not only is this an immediate loss but the effects will be felt more severely as time passes. The Forest Service of the Agricultural Department is doing splendid work in fire prevention which can be appreciated by facts recently published in relation to what was done in the Boise national forests in Idaho during the past summer. Thirty fires occurred in this region yet twenty eight were held down to less than ten acres and of these fifteen were less than one quarter of an acre. The supervisor says this success was due to a lookout tower and to efficient telephone and heliograph service.

* Adapted from Capt. Engel's article in *Prometheus*.
† Radio Review.

"Suction" Between Passing Ships—I*

Important But Little Understood Forces Affecting the Motion of Vessels

By Sidney A. Reeve, M.E.

"SUCTION" is a term commonly applied by pilots to at least three distinct hydraulic phenomena associated with moving vessels, between which phenomena they distinguish most vaguely, if at all. These three quite independent actions are

1. The direct impulse embodied in the streams of water projected astern by screw or paddle, independently of any motion of the ship itself.

2. The direct effect of the mass of water which follows a ship bodily when it is moved slowly through restricted waters.

3. The indirect, or lateral pressure, effect of the fore-and-aft acceleration of the water displaced from bow to stern during normal motion through the water at full speed.

Of these, the first two are most simple and obvious, hydraulically speaking, because there the force exerted is aligned with the water's motion. In the case of the last, the force developed hydraulically acts at right angles to the line of the water's motion. The first two need no explanation, and have nothing in common (speaking scientifically) with the third. They play an insignificant part, if any at all, in the majority of "suction" collisions, and are mentioned here chiefly for the purpose of eliminating them from further discussion. They are of frequent occurrence in the daily handling of shipping about crowded wharves, and for want of another name, or in lack of official definition, they are frequently called "suction" by the (American) Admiralty Courts; but because they are seldom of sufficient violence to be of importance, and because they are more of the nature of a "puff" than a "suck" the term "suction" will be used here as excluding them.

Historically speaking, while the science of hydrodynamics has been developed chiefly by British—or, at most, European—students, yet the recognition of suction as a feature of importance in navigation has arisen virtually exclusively in American experience. The sources of information are the books and the Admiralty Court records. Previous to the Olympic-Hawke collision in 1911 there was no literature on the subject known to the writer, excepting Taylor's paper of 1909, describing his Washington experiments. Search of the British Admiralty records by deputy discloses not a single reference to the subject. Marsden's "Collisions at Sea" (London, 1910) makes only a single reference to "suction," saying.

"A vessel will be held in fault if, without necessity, she navigates so close that . . . . she is affected by the wash or suction of the ship ahead and will not answer her helm,"

referring by footnote to the American cases of the McCandless, Manel, Brockton, and Chicago. No search of French or German court records has been made, but the principal German work devoted to ship collisions ("Der Zusammenstoss von Schiffen," Dr. Richard Prien, Berlin, 1899) makes no mention of the subject, which could hardly have happened had it ever been discussed by the German, or even by any European, courts.

In American waters the earliest instances of ship-action which were probably suction, although not given that name, occurred in 1846 and 1847, in the "Naugatuck"-"Rhode Island" and "Governor"-"Worcester" collisions. By 1869 the phenomenon had found official name, as "suction," in the "Narragansett"-"Providence" collision. From that time forward the appearance of the thing was frequent, albeit at irregular intervals. In 1871 are recorded two cases, in 1877 two, in 1880 five, in 1883 one, etc. All of these occurred in restricted inland waters. In 1885 occurred the first case involving Atlantic liners, when the "Aurania" and the "Republic" came together by suction outside Sandy Hook (but not in deep water).

Excepting possibly the records of the Naval Courts of Inquiry, which are inaccessible, the sole source of data as to actual cases of suction collision is the testimony before the Admiralty Courts. This testimony, it must be understood at the outset, is almost universally incompetent and contradictory. England's sole experience, the "Olympic"-"Hawke" case, was merely typical in this respect. The trouble is not that the witnesses are incompetent as navigators. The trouble is that navigation normally makes no demand for the estimate of the distances in feet or yards. The pilot is accustomed to gauging his distance from outlying buoys or other ships in terms of his vessel's speed or rate of swing, but not in feet. Again, when called upon afterwards for the data essential for an analysis of the collision, he can give, instead of systematic observations or estimates, only his subconscious guess as to what must have been the conditions in order that the known results should have followed, which he does in perfect sincerity. Or even if estimates were actually made, they must have been made at times of great excitement and responsibility, when positions were altering rapidly, and when the pilot's mind was properly occupied with other things.

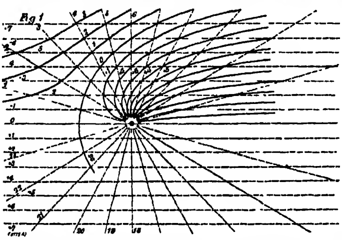
In one case the witness was the captain of a prominent trans-Atlantic liner, a man of dignity and experience. As he testified, the writer plotted the ship's position on a large scale-chart. Had the statements been correct, the ship must have been aground all the way down the harbor. Yet so obvious was the skill, experience, and sincerity of the witness that even opposing counsel made no attempt to impeach his statements. Both sides accepted the testimony as competent to prove that his ship was well over to that side of the channel on which he (virtually) testified that she was aground. In another case the court found, from the combined testimony of competent witnesses, that it was a physical impossibility for a collision to have occurred; but since both vessels were injured the hypothesis as to the facts is necessarily a compromise which includes a collision.

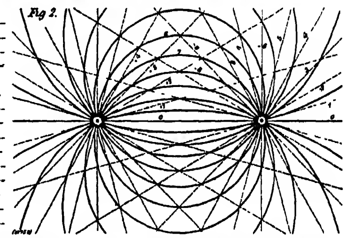
For all these reasons the formation of any accurate deductions as to the distance or angle at which suction becomes an overwhelming force is an impossibility, even for any one case. When the influence of such widely varying factors as ship-model, speed, sea-bottom, etc., is included, it becomes obvious that any hope of securing from experience or theory a *quantitative* law of suction must be abandoned at the start. But even without this, a *qualitative* understanding of the forces at work in "suction" can be of the greatest value in warning pilots as to the general conditions under which it is liable to occur, and as to where a larger margin of caution than usual is needed. For such a qualitative understanding of "suction" a brief incursion into theoretical hydraulics is necessary.

Stream-lines: "Sources" and "Sinks."—Imagine a body of water of uniform depth and unlimited lateral extent, in which is placed vertically, and extending from bottom to surface, a straight pipe of small diameter. Imagine the sides of this pipe everywhere perforated with many small holes, so that it can discharge or take in water on every side throughout its entire length. Let it be connected at the foot with some unlimited reservoir of water below the sea-bottom, so that it can draw water from this reservoir or discharge into it to unlimited extent, just as a "grounded" wire can draw electricity from the earth, or discharge into it, without limit. Disregard all question of friction of flow within the pipe, so that the capacity of the pipe for handling water is independent of its diameter, the speed of flow being anything imaginable. Therefore, for convenience, let the pipe be represented, in plan, by a geometric point.

Such a point as this, when drawing water from below and discharging it into the sea, is called a "source." When the flow is in the opposite direction it is called a "sink." Thus a source would radiate water horizontally in the sea, away from it as a center, in all directions equally. Conversely, a sink would draw water to it horizontally in all directions.

"Stream-lines" are mathematical functions of the volume of flow of water which can be represented conveniently and accurately on fields of co-ordinates, and which can be added, subtracted, etc., like other mathematical quantities. They may be of any imaginable form, and may be either of two or of three dimensions. For present purposes, no presentation of the mathematics of stream-lines is needed; nor do we need the three-dimension functions, which are much more intricate to handle than the two-dimension. Only those particular forms of two-dimension lines which pertain to the analysis of "suction" will be mentioned, and for an understanding of their mathematics the reader is referred to the bibliography listed later herein.





From a "source," or toward a "sink," radiate straight stream-lines, like the spokes of a wheel. Physically speaking, each stream-line represents a sector of flow of water, measured from some radius taken arbitrarily as a zero axis around to the radius or stream-line in question. Therefore the angle between zero axis and stream-line is the mathematical measure of its quantity, and this quantity of flow is the same at all distances from the center. Any convenient angle may be taken as the unit angle, or an arbitrary quantity of flow may be taken as the unit. According to the number of such units stream-lines radiating from a "source" or "sink," the latter is said to have different "strengths."

In a canal of uniform, rectangular cross-section, in all portions of which the rate of flow was the same, the stream-lines would be straight lines parallel with the banks. The distance from the bank would be the mathematical quantity of the stream-line.

Fig. 1 shows the addition of two such sets of stream-lines, resulting in a third set. The radial stream-lines are given numerical values, from "zero," at the axis of the figure, around to "24" for an angle of 360 degrees. The parallel lines are given similar values—positive below the axis, and negative above. Selecting any desired value for a resultant stream-line, the line can be located as passing through the intersection of each pair of original lines the sum of whose values equals the desired value. Resultant lines are thus found having values ranging from "zero" for the stream-line crossing the axis at right angles and rising above it, increasing around to the right until the same line below the axis has the value "24." From the "zero" resultant line above and to the left are lines having negative values. Below and to the left are those having values above "24." Both positive and negative series extend indefinitely away from the center of the figure.

Such a set of resultant stream-lines would give the effect of placing a "source" or a "sink" in a uniform

* Reproduced from *Engineering*

current, the current flowing to the right if the point be a source, or to the left if it be a sink Fig 2 gives the stream-lines resultant from compounding a source with a neighboring sink in still water Fig 3 gives the lines resultant from compounding a source and a sink in a uniform current, or from moving a source and sink together through still water (The resultant lines are restricted for clarity to one out of the four quadrants of the figure but they obviously exist alike in all four quadrants) The latter condition gives us our first mathematical approximation to the displacement of water from bow to stern of a moving ship

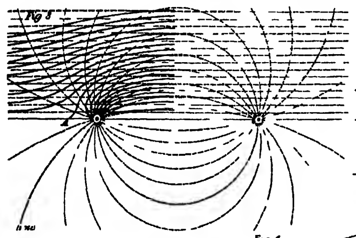


Fig 3

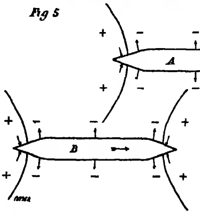


Fig 5

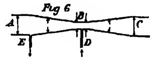


Fig 6

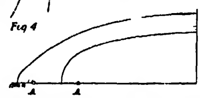


Fig 4

In Fig 3 the stream line A when completed, gives the first suggestion of the water line of a ship If we imagine the water encompassed by this stream-line in a sea of uniform depth equal to the draught of a ship to be solidified without change in volume this solid would form a ship body having vertical sides and a rectangular cross-section and the motion of this ship body through the sea at the speed represented by the parallel lines of current would develop stream lines in the surrounding sea which would be mathematically equal to those developed by the combination of moving source and sink The source represents the water thrown off by the bow to open passage-way for the ship while the sink represents the regathering of this water under the stern to fill in the trough cut by the ship's passage

The 'source-and sink' method thus opens a door to the exact analysis of the displacement of the sea by a passing vessel It is a method to which much time has been given by many able men. Originally it was cultivated as a means for designing ships of perfect form which should be capable of waveless progress through the water with minimum resistance but its very limited value for this purpose was realised long ago Now the problem of "suction" offers it a new application

By far the most ingenious and the cleverest development of the stream-line theory for actual ship-models has been contributed by United States Naval Constructor Taylor He read two papers before the Institution of Naval Architects (British) one, in 1894, on "Two-dimension Stream-lines," and the other on "Three-dimension Lines," in 1895 Taylor conceived the idea that if it be permissible to compound the stream-lines from two finite sources and sinks as Rankine did or from several finite sources as other computers did afterwards it is equally permissible to increase the number of sources and sinks indefinitely each source becoming correspondingly reduced in strength until an infinite number of infinitesimal points form the basis for integration into stream lines In other words the fore half of the ship is represented by one (graphical) function of sources of varying strength while the after half has a similar function of sinks By a very ingenious method of graphical integration without which the computation of even a few finite sources becomes intolerably burdensome the stream lines are deduced from these assumed functions For the details of Taylor's method the reader is referred to his papers [1]

Mr Taylor made tests of the force of suction between two ship-models towed in fixed parallel position in the testing-tank at Washington in 1909 and these were reported to the (American) Society of Naval Architects and Marine Engineers He repeated similar tests before the British Admiralty Court sitting on the case of the Olympic - Hawke collision during the winter of 1911 1912

The author's connection with the development of the theory of suction began in 1908 when he was called upon to explain the suction collision between the United States and the Monterey coastwise liners in New York Bay The trial being already under way when he was first approached, there was time only for the preparation of crude diagrams But in connection with the Denver Lehigh case later that same year and in the case of the Parima and the Prinzessin Irene still later, these diagrams were got up more carefully They discussed merely the general outline of the constrained wave that for one ship being drawn on transparent cloth, so that it could be slid over that for the other ship, to show how suction forces were developed by those two outlines getting into and out of phase This so far as the author is aware was the first publication of any general theory of suction Yet it is proper to state no further developments to which the writer has been able to carry this general theory toward exactness in terms of particular ship-lines have appreciably altered this first explanation which was based upon hydraulic facts which are familiar to every pilot and ship owner

II SHIP WAVES AND SEA CONTOURS

In all the earlier writers and persisting in some textbooks to the present day there is a confusion as to classification of the several sorts of ship resistance which must be cleared before the navigator taught in those years can understand suction clearly These resistances are now distinguished as (1) skin friction, (2) wave-making, with sometimes a third, eddy making which is really a part of (1) At present these resistances are mentioned only for the purpose of excluding them from the argument Suction depends solely upon the existence about every moving ship of (3) the constrained wave which is quite distinct from the bow stern and echelon waves of the usual analysis of the wave-making resistance But it was not until 1898 that there appears in the papers of the Institution of Naval Architects (British) any realization (by B Schieldrop of Bergen) that the 'constrained wave' is distinct from those other resistances in cause as well as in character

The constrained wave of a ship is not a true wave at all The true waves are classified as (a) bow waves (b) stern waves and (c) echelon waves All of these are visible disturbances of the sea surface which travel away from the ship by their own inertia, when once started and with which all seafaring people are familiar

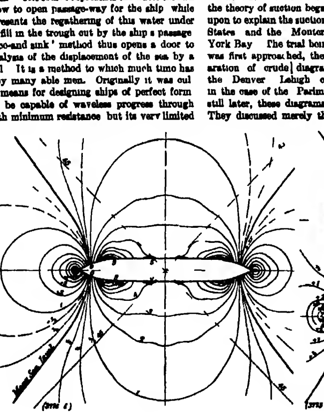


Fig 7

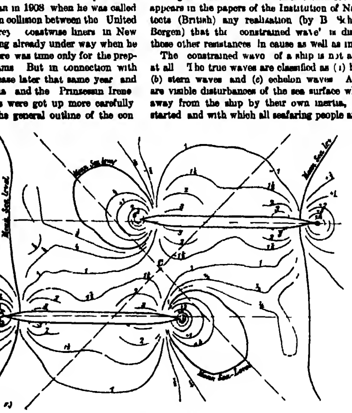


Fig 8

The constrained wave on the other hand is often invisible and usually needs to be looked for even when visible It consists of a wide low mound of water which the ship piles up ahead of herself and which accumulates until enough surplus pressure is gathered to start the water into motion aft beneath or around the hull Its height is very low like a ground swell, but its bulk is tremendous Its trough may be seen on either beam amidships, and at the stern rises a second low crest Although it is relatively to this that the true waves

[1] On Ship Shape Stream Forms by D W Taylor Transactions of the Institution of Naval Architects 1894 vol xxxv page 385 Engineering vol lvii page 410 On Solid Stream Forms and the Depth of Water Necessary to Avoid Abnormal Resistance of Ships, by D W Taylor Transactions of the Institution of Naval Architects, 1895 vol xxxvi page 234 Engineering vol lix page 459 and 497

rise visibly, yet the "constrained wave" itself is visible about every fast vessel, and in tugs it often rises a fair fraction of the freeboard, the hull "squatting" visibly into its trough.

This "constrained wave" may be explained in terms of the stream-line analysis. The two-dimension stream-line presupposes that the sea is of uniform depth, that the ship's sides are everywhere vertical, reaching to the sea bottom, and that the sea is covered with a thin sheet of rigid ice, strong enough to prevent any vertical alteration of sea surface. This ice may be supposed not to interfere with the motion of the ship, or the ship may be a submarine just reaching from the bottom to surface. Under such conditions alone would the motion of the water displaced by the ship's motion be purely horizontal Under such conditions the increase in pressure necessary for accelerating the water away from the bows, and that engendered by its arrest at the stern again, would remain purely *pressure*, confined by the rigid ice against rising in surface-waves.

But in actuality there is no ice. The increase in pressure ahead of and astern of the ship actually occurs, but it is partially relieved at the sea-surface. A readier means for the release of the water than *horizontal* acceleration is *vertical* acceleration. The water gets out of the ship's way by rising vertically from either bow, in waves. The most striking instance of this is the tiny jet of water often appearing right at the stem of river steamers. This water is displaced by a hull of rectangular outline, but small dimensions (the stem), which is propelled at disproportionate speed by a relatively enormous power; hence the vertical acceleration of the water is exaggerated.

But a more common form of vertical acceleration is seen in the "bow waves," which rise on either bow, and repeat themselves in a series extending obliquely aft along lines making angles of about 23 degrees with the ship's course, ultimately merging themselves with the echelon waves. From the stern trail away two similar series of "stern waves," but much smaller than the bow waves. On either beam, and all across the wake, spreads the procession of broad, low echelon waves. All of these are due to *vertical* acceleration of the water due to the lack of constraining ice, and all of them constitute deductions of energy from the "constrained wave," which is normally due to purely horizontal acceleration of the water

In actuality, too, there is always room for some water to escape beneath the ship's bottom, instead of spreading out laterally. In deep water this is the path for most of the displaced water. But in shallow water this path is cut off. Even where there is a foot or so of water between hull and sea-floor this space is useless for passage of water, because of the turmoil of eddies. And since the force of suction is developed only by an acceleration of water, which finds its pure and best expression only when the ship extends to the bottom, while the sea-surface is constrained by imaginary ice, these are the conditions which will be assumed throughout the discussion. All question of bow waves, echelon waves, etc., is thus eliminated.

In such a sea let there be held a vertical pole, extending to the bottom, which is then moved horizontally. This is like a vertical pipe having perforations in its sides, the side looking toward the course ahead being a "source," while the after side is a "sink." Imagine two lines drawn on the chart through the point representing such a pole, at angles of 45 degrees with its course, forming four quadrants one ahead, one astern, and one on either beam. The theory of stream-lines shows that in the quadrants ahead and astern the sea-pressure is greater than normal, so that, if there were no ice present, the sea-surface would be elevated above normal. In the quadrants on either beam, conversely, the sea-pressure is less than normal, so that, in the absence of ice, the sea-surface would be depressed. The 45 degree lines are the loci, or contour lines, of mean sea-level.

Such a four-phased distortion of the sea-surface actually accompanies every ship. Its exact form is influenced by the ship's model and by the energy leaking away in vertical wave-forming acceleration. But, in essence, it is always there, approximating the 45-degree lines in mean sea-level contour It is due solely to horizontal motion of the water, and it constitutes virtually the sole force causing suction.

This "constrained wave" is not properly a wave at all. It does not proceed by its own inertia, but is held constrained, as to form and magnitude, by the environing solid ship and sea-bottom It is stationary relatively to the ship. Its inertia plays no part so long as the depth remains constant. When that varies, however, the inertia of the constrained wave becomes the most powerful force controlling the ship. For while its head is low so low as usually to be invisible—yet the mass of water involved is enormous. It extends away from the ship indefinitely, decreasing with distance, but still perceptible at several ship-lengths away.

The form of this constrained wave is markedly distorted near the ship, away from the simple 45-degree lines of mean sea-level developed by the pole, by the lines of the ship. It will be necessary to trace further in detail these influences before the constrained waves of actual ships can be studied for suction purposes.

Every moving ship acts approximately like the vertical pole just imagined as moved horizontally through the water—viz., to distort the sea-surface about it in four quadrants, demarked by oblique 45-degree lines through its center of displacement. The quadrants ahead and astern exhibit surplus pressures, or elevations, of the surface above mean sea-level. The quadrants on either beam show deficits below mean sea-level; but in the case of the actual ship its elongated form distorts the 45-degree lines near the ship into curves of a hyperbolic form, asymptotic to the 45-degree lines, meeting the hull on either bow or either quarter.

In Fig. 5 are shown two ships in water-line plan, *A* and *B*, overlapping each other on parallel courses. The hyperbolic contours of mean sea-level are shown extending from either bow and quarter; the plus and minus signs indicate the surplus and deficit of sea pressure in the neighborhood of each ship, while the net horizontal pressure upon the hull is shown by arrows—an arrow heading toward the hull indicating surplus, and one heading outwardly a deficit, of pressure. The ships will be assumed to be moving toward the right, although the curves would be the same (in this particular case) for motion in either direction.

Without attempting now to indicate the exact form of these curves, which will be discussed later, it is plain at a glance that the two sets of plus and minus signs must cancel each other, to some degree at least. Thus ship *A* will have its lateral pressures along its starboard bow *increased* by the influence of *B's* forward quadrant of surplus pressure, while the pressures along *A's* starboard quarter will be *decreased* by the influence of *B's* port lateral deficit of pressure. Since the normal sea pressures along *A's* port side are virtually unchanged by *B's* presence, *A* will feel a tendency to swing to port.

Following the same reasoning as to the effect upon *B* of *A's* starboard and astern quadrants, it appears that *B* must feel a tendency to swing to port also. But whereas *A's* swing in response to these forces carries her away from their origin and decreases the danger of collision, except with objects on *A's* port hand, any slight response of *B* to these forces will very rapidly exaggerate them and accelerate her approach to *A's* quarter.

To the engineer, the situation may be clearer if explained in terms of the familiar Venturi meter, a diagram of which is given in Fig. 6. In the Venturi any surplus pressure existing within the conduit at either end, as indicated by the arrows, is altered more or less into a deficit at the "throat" *B* by the restricted diameter, and the consequent acceleration of the water at this point. If a branch pipe *D* be connected at this point, the deficit may be enough to draw fluid in through this pipe, although water might flow outwardly with force at *E*. Or, if the Venturi be made of flexible material, when the flow has reached a certain velocity the deficit of pressure at *B* will cause the walls to collapse; and this collapse will be sudden and violent, in unstable equilibrium.

Now the space between the two ships of Fig. 5 offers the most direct pathway for the water which, displaced by both vessels, must get from ahead to astern by some way or another. But it forms a *restricted* pathway, with gradual convergence and divergence of solid walls on either side of the "throat." In all this it is quite like a Venturi. But if ship *B* swings a bit to port it creates a situation quite like the first "give" of the throat of the flexible Venturi—the forces engender their own acceleration, in unstable equilibrium, and the motion, once started, accelerates rapidly to a sudden and violent end.

Since the situation of Fig. 5 is usually created by a larger, faster vessel overtaking a smaller, slower one, the latter finds itself first in the *A* position; but this is the position of less danger and is often passed without mishap. But when the smaller vessel has dropped back into the *B* position it is in the greatest danger. The majority of suction collisions occur in this position, the overtaken vessel suddenly swerving uncontrollably—usually in defiance of a hard-over helm, and often against reversed engines—into the quarter of the other vessel.

Usually, of course, the larger vessel is unaffected by the forces engendered mutually between the two; but sometimes it is the larger vessel which is the slower one. Indeed, the recorded instances of suction seem to include every conceivable combination of circumstances which could set these forces at work, with various results. Frequently the ship in the *A* position is driven off her course enough to collide with other vessels, or with a bank. In one instance, a large freighter going down New York Bay, when overtaken by a liner, was swung eight points off her course by this repellent component of the "suction" forces—fortunately having sea room enough to check her way before running aground—but was left in that position helpless until the liner was well by.

For it is obvious that the forces created by these "constrained" waves following and preceding the ships can easily be far greater than any of those ordinarily relied upon for maneuvering. While the altitude of the constrained wave is slight, its extent covers an area of ship-side which is enormous when compared with the rudder surface. Indeed, the difficulty in connection with suction is not to explain it, but to explain how it is that so many ships pass closely without its becoming an overwhelming factor. The most frequent answer is, *depth of water*. It requires no mathematics to show that this Venturi-like restriction of waterway between the two ships is much worse in shallow water than in deep. But suction collisions sometimes occur in water which, while not very deep, provides enough space beneath the hulls to pass a good deal of water; while in quite shallow water vessels often pass very close in safety. To answer these questions the exact form of the constrained wave needs further consideration.

(To be concluded.)

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JANUARY 9, 1915

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876)	per year	$5.00
Scientific American (established 1845)	"	3.00
American Homes and Gardens	"	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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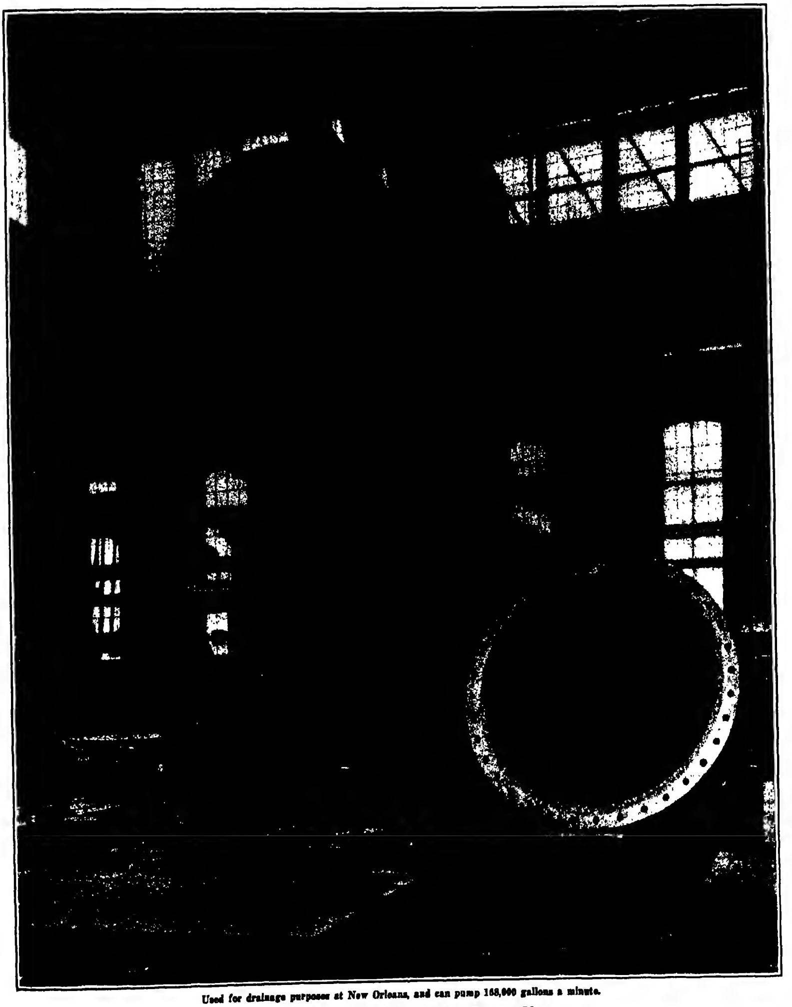
VOLUME LXXIX NUMBER 2037 — NEW YORK, JANUARY 16, 1915 — 10 CENTS A COPY $5.00 A YEAR



Used for drainage purposes at New Orleans, and can pump 168,000 gallons a minute.

THE LARGEST CENTRIFUGAL PUMP.—[See page 37.]

Ozone in Ventilation*

An Exposition of Faulty Methods of Investigation Heretofore Employed

By J. C. Olsen and Wm. H. Ulrich

In spite of the fact that a great many investigations have been carried out in recent years on the effect of ozone on air, bacteria and odors and also on the physiological effects of ozone, the most diverse conclusions have been reached and opinions expressed with reference to the questions investigated. This confusion is due somewhat to faulty scientific technique and deductions from improperly chosen experiments as well as erroneous point of view. The most recent criticisms against ozone in ventilation are found in two articles which were published in the issue of September 27th, 1913, of the *Journal of the American Medical Association*, one by Jordan and Carlson and the other by Sawyer, Beckwith and Skolfield on the bacteriocidal, physiologic and deodorizing action of ozone. A number of errors in the methods used in the experiments given in these articles have been noted, and these seem so serious and the articles have been so widely quoted that it seems desirable to correct the misapprehensions which have been produced. Both of these articles refer to the fact that exaggerated claims were made by agents selling ozone machines.

In the article by Jordan and Carlson it is stated on page 10 that the concentration of ozone is determined by drawing the ozonized air through a solution of potassium iodide which has been acidified with sulfuric acid. The liberated iodine is then titrated with thiosulfate solution. It is well known among chemists that an acidified solution of potassium iodide is readily oxidized by the ordinary oxygen of the air and therefore if an acidified solution of potassium iodide is used for the determination of ozone the results will be high. The amount of the error will vary with the concentration of the ozone and may easily give results double the true concentration of ozone. This error can easily be demonstrated by drawing air free from ozone through such an acidified solution of potassium iodide. It is evident therefore that no reliance can be placed on the figures given for the concentrations of ozone which are reported in this article. In the article by Sawyer, Beckwith and Skolfield the concentrations of ozone were not determined.

It is universally recognized by ventilating engineers who are familiar with the use of ozone that it is of the greatest importance to regulate the concentration of the ozone and that ozone is useful only when employed in the proper concentration. This well known principle seems to have been so little understood by these investigators that they failed to make careful and accurate determinations of the concentrations of ozone used and therefore many of the conclusions which they reached are entirely vitiated.

Another very serious error in experimental procedure is found in the tests which were made on the effect of ozone on odorous substances. A considerable number of such substances were experimented with, and the conclusion was reached that the ozone *masks* these odors but does not destroy them and that therefore ozone is not useful in the removal of such odors.

The method of procedure consisted in exposing the substance giving off the odor until a marked odor was noticed in the small closed room which was used for the experiments. The ozone machine was then operated until a strong odor of ozone was produced. Observations were made from time to time of the odor in the room and it was observed in a good many cases that the ozone odor gradually disappeared and the odor of the substance experimented upon returned. In some cases ozone was again generated until its odor was pronounced and observations again made with reference to the disappearance of the ozone odor and the reappearance of the odor of the substance experimented upon. The conclusion was drawn that the ozone did not destroy the substance giving the odor but masked it. This conclusion was based upon the disappearance of the ozone odor and the return of the other odor. No other evidence whatever on this point is presented.

In these experiments no attempt seems to have been made to determine the amounts of the odorous substances which were present in the air except by the odor. The experimenters apparently did not consider the fact that the odors of substances differ a great deal in intensity, and that the quantities of substances which would be present, even though the intensity of the odor was the same, would differ very much. These authors also failed to keep in mind that the destruction of odors by ozone is an oxidizing process and that this, as well as all chemical reactions, is quantitative in the sense that a definite amount of oxygen is required to oxidize a definite amount of an oxidizable substance.

The following reaction takes place when ozone oxidizes hydrogen sulfide:

$$H_2S + O_3 = H_2O + S + O_2$$

That is, 34 parts of hydrogen sulfide would require 48 parts of ozone for their oxidation. When the hydrogen sulfide is dissolved in water the sulfur liberated is still further oxidized by the ozone to sulfuric acid, which would require a still larger quantity of ozone but according to the reaction given a somewhat larger amount of ozone than hydrogen sulfide would be necessary for the destruction of this substance. Now if the intensity of the ozone odor is much greater than that of the odor of hydrogen sulfide the hydrogen sulfide would be oxidized by the ozone in the experiments reported by Jordan and Carlson and some other authors quoted and the hydrogen sulfide odor would then return as reported by these investigators.

In order to verify these conclusions experiments were carried out to ascertain the amount of hydrogen sulfide which will give a distinct odor. A large balloon flask of 30 liters capacity was used. The hydrogen sulfide was produced by treating known weights of carefully analyzed iron sulfide with dilute sulfuric acid. The reacting substances were placed on a watch crystal suspended in the center of the balloon flask. In addition to the odor tests were made with lead acetate paper.

INTENSITY OF ODOR OF HYDROGEN SULFIDE

Mg. H_2S per Cubic Meter	Test with Lead Acetate Paper	Odor
977	Very black	Very strong
244	Very black	Strong
61	Very black	Distinct
30	Turned black slowly	Fairly distinct
15	Brown on edges	Faint
7.6	Turned brown very slowly	No odor

While to obtain a distinct odor of hydrogen sulfide 61 parts are required the odor of ozone is very marked when present to the extent of one part per million, the limit being one-tenth part per million. In the experiments of Jordan and Carlson, the concentration of the hydrogen sulfide must have been from 30 to 60 milligramme. One part of ozone would have given a strong odor which could mask the odor of the hydrogen sulfide until by the oxidation of the latter the ozone was decomposed. Less than one part per million of the hydrogen sulfide would be destroyed by this oxidation leaving a sufficient amount of hydrogen sulfide to give a very distinct odor. On again generating ozone until a strong ozone odor was obtained, the hydrogen sulfide would be again masked and when the ozone odor had disappeared the hydrogen sulfide odor would reappear. This could be done repeatedly, as reported by Jordan and Carlson. The conclusion which they drew, however, is entirely unjustified, namely, that their experiments showed that the hydrogen sulfide odor was merely masked and hydrogen sulfide not oxidized or destroyed by the ozone.

In order to verify this conclusion, the following experiment was carried out. A concentration of 25 milligrammes of hydrogen sulfide was treated with ozone of a concentration of 35.6 milligrammes per liter. In these concentrations there would be just enough ozone to oxidize the hydrogen sulfide. In this experiment the ozone odor was at first very pronounced but after this odor had disappeared there was no hydrogen sulfide odor. A slight acidity was indicated by the reddening of blue litmus paper. The ozone used had been very carefully tested for nitrous oxides, but none was found.

Another experiment was carried out in which the ozone concentration was 7.6 parts per million, while the hydrogen sulfide concentration was 60.7 milligrammes per cubic meter, so that only a small part of the hydrogen sulfide could be oxidized by the ozone present. At first only the odor of the ozone could be detected. The hydrogen sulfide odor gradually returned so that within one hour a faint, and after two hours a distinct, hydrogen sulfide odor was detected, while the ozone odor had entirely disappeared.

This experiment could be repeated three or four times, as reported by Jordan and Carlson on page 33 of their article. They further state: "The mechanism of this masking action of ozone does not concern us here." If the authors had considered the "mechanism" of this action they might have reached entirely different conclusions and would have seen that their experiments were in exact accordance with the theory that ozone oxidizes hydrogen sulfide and other substances. They still further refer to the fatigue of the olfactory end-organs by the ozone. They say "Strong concentrations of ozone rapidly fatigue or anesthetize the olfactory epithelium." One wonders why the authors did not make this statement general, and state what every chemist has frequently observed, that hydrogen sulfide and the numerous other odors which are present in chemical laboratories produce the same effect on olfactory epithelium, so that these odors are not noticed by workers in the laboratory.

Hydrogen sulfide is also oxidized by the air, as is shown by the fact that the odor slowly disappeared in a duplicate experiment in the absence of ozone.

In some cases ozone acts as a catalytic agent. This was shown by the action of ozone on linseed oil. Weighed quantities of linseed oil were exposed to air and ozone. The oil exposed to air gained 17 milligrammes, while an equal quantity exposed to the action of ozone gained 110 milligrammes during the same time. The amount of ozone generated was 11.4 milligrammes. The ozone, therefore acted as a catalytic agent, causing the absorption of 82 milligrammes of oxygen, which is nearly five times as much oxygen as was absorbed by the oil exposed to air alone. It is reasonable to suppose that ozone would act as a catalytic agent and cause the oxidation of other oils and organic substances similar to linseed oil.

In the case of ammonia the same considerations apply. Ammonia is oxidized by ozone in accordance with the following equation:

$$2NH_3 + 3O_3 = N_2 + 3H_2O + 3O_2$$

In this case, one part of ammonia is oxidized by about four parts of ozone. A study of the intensity of the odor of ammonia gave the following results:

INTENSITY OF THE ODOR OF AMMONIA

Mg. NH_3 per Cubic Meter	Test with Litmus Paper	Odor
1 000	Turns blue readily	Strong
659	Turns blue slowly	Fairly strong
329	Turns blue slowly	Fairly strong
165	Turns blue very slowly	Fairly strong
82	Turns blue very slowly	Quite distinct
41	Turns blue on edges very slowly	Faint
21	Turns partially blue on edges very slowly	Very faint
10	No action	No odor

Experiments were carried out in which known amounts of ammonia were treated with definite amounts of ozone and the ammonia remaining was determined by absorption with sulfuric acid and nesslerizing. Ammonia is acted upon very slowly so that 24 hours were allowed for the reaction. The concentration of the ozone was 35.6 milligrammes and of the ammonia 125 milligrammes per cubic meter. After 24 hours, 78 milligrammes of ammonia remained in the flask containing air and 75 milligrammes in the flask containing ozone. The quantity of ozone present was sufficient to oxidize 8¼ milligrammes of ammonia per cubic meter. The experiment indicates some oxidation of ammonia by ozone. Erlandsen and Schwartz[1] state that their results showed no action of ozone on ammonia.

Experiments were also carried out to ascertain the intensity of the odor of oil of cloves. It was found that 66 milligrammes per cubic meter would give a strong odor. The amount of ozone necessary to oxidize oil of cloves cannot be calculated exactly, but it would probably require several times more than an equal weight. On subjecting the oil of cloves vapor in a concentration of 36.6 milligrammes per cubic meter to the action of ozone of a concentration of 33 milligrammes per cubic meter, it was found that at first a distinct odor of ozone could be detected, which gradually disappeared and was replaced by a sweet odor which had no resemblance to the strong odor of the oil of cloves. Very evidently the oil of cloves, or one of its strong smelling constituents, is oxidized, at least partially, so as to leave an organic compound having an entirely different odor. The flask was allowed to stand a total of 27 hours, although the reaction was practically complete within 2 or 3 hours. The reaction did not seem to be entirely regular. The experiment was repeated several times and the formation of the sweet aromatic substance repeatedly observed, but at times the odor of cloves persisted. Any excess of ozone was removed by shaking with 10 per cent ferrous sulfate solution. Control experiments were also made with a balloon flask containing oil of cloves and air only. Erlandsen and Schwartz have made a similar observation with respect to skatol and indol. They state that these substances are completely decomposed by ozone with the formation of pleasant smelling substances similar to [illegible]. They also state that mercaptan is rapidly decomposed by a large excess of ozone.

*Read at the 8th Semi annual Meeting of the American Institute of Chemical Engineers, Troy, New York.

[1] Zeit. f. Hyg., [illegible]

These authors also found that hydrogen sulfide is oxidized by ozone. Jordan and Carlson also mention the work of Erlandsen and Schwarts, but state that the results of the latter agree with those of Jordan and Carlson in showing that ozone *masks* odors and does not oxidize the substances discussed Jordan and Carlson even state that "The inability of ozone to oxidize (to any appreciable extent) ammonia vapor and oil of cloves is very striking" Franklin gives the results of experiments showing the oxidation of a great many organic substances, and demonstrated that carbon monoxide is oxidized to carbon dioxide [1]

Undoubtedly many of the conflicting conclusions which have been reached are due to the failure of experimenters to take into account the quantitative relations between ozone and the substances to be oxidized and have generally failed to realise that on account of the much greater intensity of the odor of ozone than that of other substances producing odor far too little ozone has been employed in the experiments The odor of ozone is at least 100 times as intense as that of other substances having a pronounced odor

The common method of using ozone to destroy odors seems to be justified by these considerations The ozone machines in good practice are operated so that a very small concentration of ozone in the air is produced The continued renewal of this small amount of ozone oxidizes the odorous substances and gives the total quantity of ozone required by chemical theory

Jordan and Carlson undertook to prove that ozone does not destroy smoke by coating a piece of glazed paper uniformly with a thin film of lampblack and subjecting the carbon to the action of ozone for 10 hours and state that there was no effect on the lampblack They regard this as evidence that ozone does not destroy smoke although they state that smoke also contains carbon monoxide sulfurous acid etc They seem to have made no attempt to study the effect of ozone on carbon monoxide and sulfurous acid, but state that the assertion that ozone destroys smoke is equivalent to a deliberate deception because ozone does not oxidize carbon particles suspended in the air Not being chemists, Jordan and Carlson might not have known that carbon is extremely difficult to oxidize, but they should have known that carbon monoxide and sulfurous acid, as well as creosote and other pungent and aromatic organic substances present in smoke, produce disagreeable and toxic physiological effects It is just these constituents of smoke which are easily oxidized by ozone The carbon which is not acted upon is totally inert and harmless

Jordan and Carlson also carried out investigations on the action of ozone on air bacteria. As has already been stated, their determination of the concentration of ozone cannot be relied upon because acidified solutions of potassium iodide were used which give high results The authors admit that the plate method which they used was not an exact one, and that therefore the results were irregular They obtained a reduction of bacteria from 64 to 38, 49 to 18, 61 to 67 (increase), 78 to 34, that is, the bacteria were reduced to 40 6 per cent, 63 3 per cent and 56 4 per cent in three tests while in the fourth there was an increase to 109 8 per cent Most authors would discard the fourth test and consider the reduction to be about 55 per cent Jordan and Carlson then tried Winslow s more exact method, but did not use a large enough sample for the test (4 5 liters), so that the highest number of bacteria counted was 7 It is not good practice in bacteriological work to rely on counts of so small a number Jordan and Carlson draw the following strange conclusion from their results

The alleged effect of ozone on the ordinary air bacteria, if it occurs at all, is slight and irregular even when amounts of ozone far beyond the limit of human physiological tolerance are employed '

There is no reason to suppose that the ozone used in these experiments was 'Far beyond the limit of human physiological tolerance ' The reduction in the number of air bacteria is not "slight and irregular" The experimental results of Jordan and Carlson agree with the results obtained by one of us[2] in New York school rooms showing a reduction in air bacteria and moulds of 75 per cent, 91 per cent and 91 per cent, the greater reduction resulting from longer exposure to ozone. No ill effects were observed on the children and adults present during these tests.

Jordan and Carlson (p 34) state "Some bacteria are undoubtedly killed by ozone, especially if they are in a moist condition." This statement is correct as it is [illegible] that ozone destroys moist bacteria [illegible]. The conclusion drawn by Jordan and Carlson is very far from being correct. They say "[illegible], however, the fact is of very slight importance [illegible] the work of Chapin, Doty and of Winslow and [illegible] have fairly disproven the belief held so long that bacteria existed as a menace in rebreathed air It has been shown that infection occurs but rarely from air-borne bacteria and then only when the *bacteria are in the moist condition* It is just these virulent bacteria which are quickly destroyed by ozone even in low concentrations The bacteria which resist the ozone are powerless to transmit disease

It is by no means necessary to show that ozone is capable of sterilising the air in order to show that it is useful in ventilation There is in fact no other disinfectant which can be used even in low concentrations in living rooms All other known disinfectants are highly dangerous in concentrations high enough to be at all effective Ozone in low concentrations will both remove odors and will materially reduce the bacteria content of the air

Jordan and Carlson attempted to show that ozone is dangerous by subjecting guinea pigs to high concentrations until the animals died They also forced strong ozone (10 parts per million) directly into the lungs of dogs and rabbits after performing tracheotomy under ether and inserting a tube well below the larynx and treating the wound with cocaine They say they did this because at least three-fourths of the ozone is decomposed by the mucous membrane of the respiratory passages It is difficult to see what bearing this experiment can have on the use of ozone in ventilation The ozone which was forced into the lungs must have been several hundred times as concentrated as it is ever used in ventilation It would have been quite as logical to place animals in pure oxygen or even an atmosphere of 50 per cent oxygen and also force these gases directly into the lungs When the animals died and the lungs were found to be inflamed the conclusion might be drawn by highly academic experimenters that it is dangerous to breathe air containing 20 per cent oxygen

Jordan and Carlson carried out experiments with what might be called low concentrations of ozone They subjected 4 cats, 4 rabbits, 6 guinea pigs and 12 rats to ozone of 1 part per million nine hours daily during two weeks so that irritation of the eyes and nose was produced Body weight, appetite and general condition were noted No ill effects on appetite and body weight or general condition could be observed The conclusion could, therefore, be drawn that ozone in moderate concentrations is harmless but Jordan and Carlson warn us that this conclusion is not justified

They say We desire to state, however that this test does not warrant the conclusion that the ozone in concentrations that may be used in practical ventilation is harmless to man Two weeks is a short time in the life of a man If ozone in ventilation should come into general use, it would mean in the case of office and shop workers exposure to ozone from 6 to 10 hours a day 6 days of the week, from 9 to 12 months of the year for from 20 to 50 years And even if this prolonged exposure to ozone should prove harmless to the robust person what about the unfortunate person whose lungs have only slight power of resistance?

Jordan and Carlson seem to have fallen into the error of assuming that because they have not tried to and therefore have not demonstrated actually, benefit from the use of ozone, this is equivalent to having demonstrated the reverse, i e, the harmfulness of ozone

If the facts presented in this paper are properly interpreted they will be found to be in accordance with the view that ozone is a powerful disinfectant and deodorizing substance which, in suitable concentration is without any injurious effects whatever The elimination of odor is by no means the least important function of ozone and there is no other agency available except dilution with fresh air In many cases it is impossible to introduce enough air for this purpose without producing annoyance and dangerous drafts of air not to mention expense of blower installation and operation as well as heating the air As a matter of fact before ozone was available, disagreeable odors have often been considered unavoidable nuisances which could not be eliminated or overcome.

With reference to the alleged harmful effects of ozone, no single instance of harm to a person from the proper use of ozone in ventilation has been published, but all adverse opinions have been deduced, by inference, as in the paper by Jordan and Carlson, from experiments performed with very high concentrations, while all efforts to produce harm experimentally with weak ozone have failed.

Jordan and Carlson report that 26 animals, exposed for 14 days, during 9 hours each day, to concentrations high enough to cause irritation of the eyes and nose, suffered no ill effect whatever Hill cites the cases of the numerous workers in the London underground tubes who have shown no ill effect in three years. Gmunder cites the unharmed workers in the spinning mills at Reutlingen, and numerous similar instances of prolonged proper use of ozone without a single complaint are today in existence. The Jordan and Carlson report is the most elaborate and convincing laboratory test that has been published.

[1] Heating and Ventilating Magazine, 10, No. 11

[2] [illegible] of Air and Water by Means of Ozone, Chem. [illegible] Congress of School Hygiene.

Report of the Bureau of Mines

The annual report of the United States Bureau of Mines issued by the director Joseph A. Holmes discloses a surprising amount of useful work accomplished and clearly indicates the inestimable value this bureau could be to the country if sufficient funds were available to enable it to carry out the work that is clearly necessary

Broadly the lines of work of the greatest national concern devolving on this bureau are the safeguarding of the lives of miners and of the employees in the metallurgical and mineral industries and the development of a more efficient and less wasteful preparation and use of our mineral resources and while the latter of these is of vast monetary concern it is the former that will appeal most strongly to popular interest One of the first directions in which this work was prosecuted was in relation to safety in coal mines and a large number of details have been investigated with good results Among these are the studies that have been made as to the causes of explosions and their prevention the use of explosives and electricity in mines ventilation and rescue work as well as many other points In the mine rescue work six mine rescue stations have been established as well as eight rescue cars and one motor truck all of which have rendered most valuable aid in cases of accidents and the bureau itself has been directly responsible for the saving of a number of lives One of the most valuable and permanently useful branches of this work has been the instruction given to miners and during the year 2,811 miners were trained in rescue work and 5,780 were trained in first aid methods At the end of the year 24,975 men had been instructed altogether and through them a knowledge of rescue work is spreading rapidly Other investigations looking to making mines safer are under way but much more could be done if greater resources were available

The importance of the work that can be done in the prevention of waste may be understood from the statement that the total wastes or losses in mining and utilizing our mineral resources now amount to more than $1,000,000 a day and when it is realized that these losses are irreplaceable the desirability of prompt action is apparent. That the bureau is doing splendid work in this direction is shown in a single item for by the expenditure of less than $15,000 a saving of natural gas has been made of not less than $1,000,000 or more than the bureau has cost since it was organized

A careful estimate indicates that in the mining of 600,000,000 tons of coal during the last calendar year there was wasted or was left underground in unminable condition 300,000,000 tons of coal and it is believed that more than half of this loss is preventable Of petroleum not less than $[illegible]0,000,000 in value is annually wasted by present methods In the ordinary process of coking coal $7[illegible],000,000 is lost annually These are but indications of the work that should be done and the directions in which the bureau is employing its activity and there are multitudes of others requiring attention One interesting study undertaken by the bureau was in regard to radium uranium and vanadium with a view to developing methods for the cheaper extracting of these valuable metals from their ores both with a view to reducing the price and to develop the radium industry in this country and stop the exportation of our ores to foreign countries where they are now treated As a result of this study which was undertaken in connection with the National Radium Institute methods for the extraction and purification of radium vanadium and uranium from carnotite ore have been devised The methods have given satisfactory results and indicate radium can be produced at a much lower price than that at which it is sold at present.

While in some quarters the narrow view is taken that anything that assists mining or metallurgy in this country will be only for the advantage of some corporations the reading of this report is convincing that the field covered by the Bureau of Mines is to the direct advantage of every citizen of this country no matter who may benefit incidentally for it is the public that pays eventually for every waste, and the cheaper and more economical production can be made in any direction the lower will be the price at which the goods can and must be sold and it is becoming more evident every day that no time should be lost by the Government in extending to our mineral industries and manufactures the aid that is so liberally given to many other departments that are conducting valuable investigations of our resources. Incidentally it may be remarked that the policy of withholding aid from the mining interests for fear it may assist some corporation is likely to be the surest way to create monopolies, for the small mine owner cannot afford to develop economical processes that will enable him to compete with the big concerns, and if the Government does not help him in this way his only resource is to transfer his property to the large corporations.

The Diary of Kilauea*

Volcanic Action in Hawaii Being Observed and Recorded

An important contribution to scientific knowledge is that just published by the Society of Arts. The institute has recognized the need of systematic observation of volcanoes and for this purpose has established in the Hawaiian Islands an observatory where with most recent methods and equipment the facts that the crater has to offer are to be collected. The work owes its initiative to the interest and activity of Prof. T. A. Jaggar, Jr., of the Geological Department, who is the director of the Hawaiian Volcano Observatory.

The report of the Hawaiian Volcano Observatory is a neat quarto of seventy-five pages, well illustrated, which gives the history of the institution and its work up to and including 1912.

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Crater of Halemaumau, about January 4th, 1912

In 1912 the observatory was put on a five year foundation and early in the year the present building was constructed. Dr. Jaggar was named head of the observatory and relieved of his duties in Boston for the purpose of making investigations at the volcano of Kilauea, where the station is located.

The institute has the lease of a tract of three acres on the brink of the crater with the option of renewal, and its station includes living rooms, administration offices and work rooms, while the Whitney Laboratory of Seismology is a basement room of concrete, floored on the solid ledge of basalt. The place of the instrument house is most striking, being on the very edge of the rim where at times the clouds from the crater encompass it. During some of the experiments it has been necessary to establish a line of assistants who by calls from one to another directed the manipulation of the instruments.

The story given in the report is largely a day by day account and valuable for scientific purposes. The conduct of the fiery lakes in the bottom of the crater is chronicled, the oscillations of the lakes within their basins, the different kinds of action, the fountains, one of which, "old faithful," was playing at intervals of thirty seconds sending fiery spray to one hundred feet in height, while the earthquake shocks of every little while are noted.

Experiments were made in gas-composition of the vapor clouds above the lakes, the flows of molten lava into fiery pools are described and the floating island. New cones on the floor of the great crater are a phenomenon of interest, the fall of the crater walls, the range of the fire with reference to surface, are features in an activity that knows no cessation.

Part of the work was that of Perret and Shepard, the former the well known vulcanologist and the latter detailed for the work by the Carnegie Institution. In this series of observations a cable was stretched across the lake and from it the thermometers were lowered into the lava to ascertain its temperature. It was a very difficult performance and one after another of the instruments were lost on account of the heat and acid condition of the vapors, which melted or corroded the wire ropes. One record was obtained, however, at 1,800 deg. Fahr., and a moment after the wire ropes were melted and the instrument lost. It was the third pyrometer thus to be destroyed, but the observation is considered to be a good one of the temperature of Kilauea lava.

One of the striking matters presented by this volume is a bit of prophecy. Dr. Jaggar thinks that there is a rhythmic escape of lava which has been fairly well verified by the records of past eruptions. Mauna Loa, which is the subject of this prediction, seems to have decreased the duration of its eruptive periods, which previous to 1868 were eleven and one half years long and since that date have been five years long. The time between those periods when the volcano has remained quiet has decreased from five and one half years to four and three quarters. Applying these figures to the last eruption Dr. Jaggar is looking for renewed activity in this volcano in February, 1915. There is really no satisfactory information on which to predict the month, but from the usual conduct of the volcano February seems the most probable. It will be of great interest to know whether this prediction made in September, 1912, is fully realized.

* Courtesy of Science Conspectus.

Food for Polar Explorers

In a recent article in the *Daily Telegraph*, London, Sir Ernest Shackleton discusses the important question of food supplies and the proper diet for explorers in polar regions, and as these are questions of vital importance in regions where temperatures not far short of 80 degrees below zero are common, as the success of such expeditions depends primarily on the health of the explorers, this article is quoted in full and will be found of general interest, particularly the tables giving the scale of food rations that has been prepared by Colonel Beveridge, of the Royal Army Medical College, particularly for this expedition.

To provide the best kind of nourishment under the long and, even at their best, somewhat trying conditions of the Polar regions is a matter of considerable thought and anxiety in the organization of such an expedition as ours. Captain Scott, whose great achievement and tragic death are ever fresh in mind, gave the matter his most careful consideration. But I believe this is the first occasion when Polar explorers will have the benefit not only of practical experience but of scientific experiments and tests which should prove of very great advantage in the coming effort.

The sledging distance to be covered will be roughly 1,800 miles, and the first half of this, from the Weddell Sea to the Pole, will be over unknown ground. Every step will be an advance in geographical science. It will be learned whether the great Victoria chain of mountains, which has been traced from Ross Sea to the Pole, extends across the continent and thus links up (except for the ocean break) with the Andes of South America, and whether the great plateau around the Pole dips gradually to the Weddell Sea. Continuous magnetic observations will be taken on the journey. The route will lead to the Magnetic Pole, and the determination of the dip of the magnetic needle will be of importance in practical magnetism. The meteorological conditions will be carefully noted, and this should help to solve many of our weather problems. The glaciologist and geologist will study ice formations and the nature of the mountains, and his report should prove of great scientific interest. This apart from the scientific work of the base parties, one of whom I shall leave on the Weddell Sea and the other of whom I hope to meet on the Ross Sea at the conclusion of my long march.

On this march, which is roughly 1,800 miles, I shall have the company of Mr. Frank Wild, my second in command, who served with distinction during an extended sledge journey during the National Antarctic Expedition 1901-4, and who was one of the southern party of my last expedition (1907-9), together with four picked men. Given favorable conditions we hope to do the journey in 90 days, but we shall take enough food with us to last 120 days, in case we meet with blizzards which confine us to our tent. The average duration of a blizzard is two or three days, but a particularly bad storm has been known to last as long as 17 days. Even therefore if we meet with the worst weather conditions we shall have plenty of supplies to the good. In the matter of temperatures the mean Antarctic winter temperature is always below zero. In summer it is about —28. On the plateau it is 40 degrees below zero, but in the spring months the temperature falls as low as 75 below zero.

Now several important considerations have to be borne in mind in selecting food supplies for conditions such as these. The food must be wholesome—it must be uncontaminated—and nourishing in the highest degree. Only by the most nutritious and (as far as possible) most varied food can one hope to hold the dread disease of scurvy at bay. There was a time when scurvy, which is often produced by eating preserved food in an unwholesome condition, used to be regarded as the inevitable corollary of a prolonged stay in Polar regions. It has been the *bete blanche* of more than one heroic effort. On the 1907 expedition we had not a single case of scurvy attributable to the food we had brought with us.

Again, food taken with us on our sledging expedition must be as light as possible in weight, and yet, contradictory as this may seem on the face of it, it must be

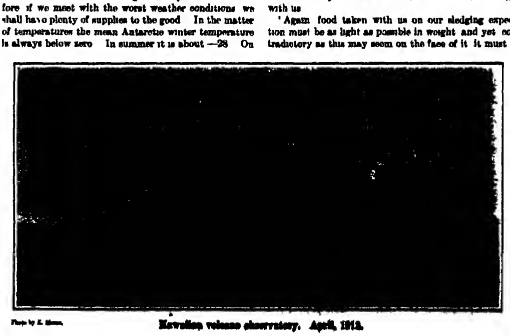


Photo by E. Moses.

Hawaiian volcano observatory, April, 1912.

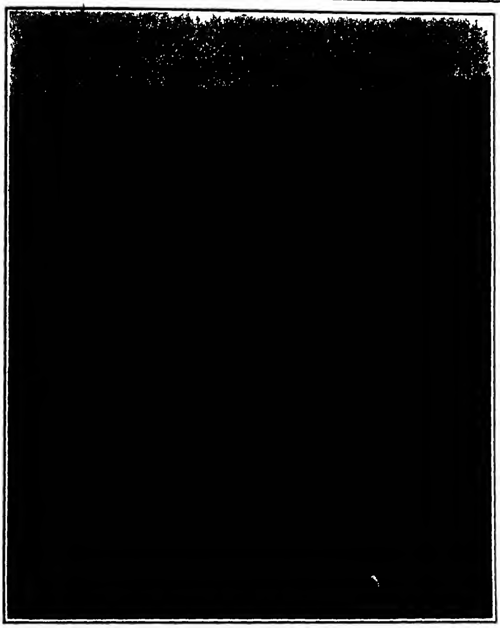


Photo by E. M. ...

Crater of Halemaumau, September 19th, 1909, looking southwest, showing travelling fountains spatter rampart and flows.

substantial. Excessive concentration not only diminishes its nutritive value almost to nil but renders it less easy of assimilation. Bulk is as essential as nutritive value. In very low temperatures the heat of the body, which is the life of the body, can be maintained only by use of fatty and farinaceous foods in such liberal quantities as circumstances allow. Then again sledging food supplies must not require much cooking. Something that can be heated easily and quickly is the desideratum, for the amount of fuel that can be carried is strictly limited, and if it runs out there are no means of replenishing it. Failing the means of heating the food it must be of a character that can be eaten without cooking at all. In winter quarters at the base camps—a great variety of food is possible.

"On our sledging journey, to which I have already referred, our rations will be 35 ounces per man per day, containing 5,512 calories. In normal life an ordinary man eats about 3 pounds of food a day, containing some 2,500 calories, so that we shall have the benefit under Polar conditions of some 3,000 calories per man.

Here are the sledging rations in total we are taking with us, calculated to last for 20 men for 100 days per man.

	Lbs
Unhulled Scotch oatmeal fine ground	500
Lard (pure)	1,000
Sugar (ground centrifugal)	150
Sugar (loaf)	300
Beef powder	375
Glidine	125
Biscuits (Antarctic, H and P.)	875
Trumilk	300
Nut food (6 ounce packets)	750
Lime juice (concentrated, made into losenges or capsules)	65
Cerebos salt (in packets containing 0.75 ounce)	16
Meat extract (in 5 ounce cubes)	65
Tea	32
Total	4,553

"The whole of it is being packed in oblong boxes of 60 pounds each (oblong because it is easier to handle and balance this shape). The boxes are made of Venesta wood, which is both light and durable. Everything in the nature of meat is in skins, which come in useful for feeding the dogs, although if necessary we shall eat the skins ourselves. I hope it won't be! These rations are going out in a refrigerator and will remain in refrigeration until they arrive at their (first) destination in the land of the Southern Cross. Among the articles mentioned in the tables given herewith, the lime juice has been concentrated down at a temperature of not more than 95 deg. Fahr., so that the anti-scorbutic properties are thereby preserved. Glidine is a vegetable proteid, while Trumilk has this advantage over ordinary dried milk, that it has not been subjected to a heat so great that the vitamines are thereby destroyed.

It will be seen that we are to have a total of 11½ ounces for breakfast. While in Norway recently we found that we could not eat two-thirds of that for our matutinal meal, and I fancy there are few men in England, even among the laboring classes, who are subjected to strenuous work, who could manage as much for the morning meal.

Our only stimulant will be tea. We shall have a small quantity of brandy with us, but only for medicinal use in emergency. It often happens that in uplifting the arms to fix the tent for sleep the blood rushes from the hands and the fingers become instantaneously frostbitten. A man is then quite *hors de combat*, but a drop of brandy will help to give a fillip to the blood in the affected parts.

In the ordinary way breakfast is taken at 6 A. M., luncheon at noon and supper at 6 P. M. But to achieve the object of our sledging journey we—I mean myself, Wild and our four comrades—propose to split up the 24 hours into a 19 hours day. That will give us 8 hours marching, 8 hours sleep and 3 hours for the preparation and taking of meals. As far as possible our 'days' and 'nights' will be arbitrarily fixed in this fashion, but our speed necessarily depends upon a variety of circumstances.

"Our last supply of fresh meat and vegetables will be taken on board at the Falklands. It may be possible to carry enough to last us a fortnight. After that we shall take to our special supplies.

"We are also taking some soil and seeds, and hope to grow just a small quantity of oats, barley, rape, mustard and cress and peas. As the green shoots come up they will be cut and made into sandwiches. We may be able to take a few of these sandwiches with us for a very special treat on our 1,800-mile tramp.

The valuable tables of the sledging rations worked out by Colonel Beveridge are as follows:

SCALE OF RATIONS

Article and Amount	Moisture	Mineral matter	Protein	Fat	Carbohydrates	Calories
BREAKFAST						
Oatmeal 2 oz	4 03	0 88	12 04	5 44	31 02	[illegible]
Lard 1¼ oz				99 21		[illegible]
Sugar ½ oz					14 17	58
Beef powder 1⅓ oz	0 99	3 8.	35 29	2 17		166
Glidine ⅘ oz	1 28	0 08	11 78	0 14	0 82	53
Biscuits 1 oz	1 52	0 30	9 21	0 87	14 47	105
Trumilk 1 oz	0 11	1 60	6 71	8 00	11 58	150
Sugar (additional lump 1½ oz					42 51	174
Total 11½ oz	9 95	6 77	75 9.	115 93	126 55	1 865
LUNCHEON						
Biscuits oz	17 00	1 50	41 0.	4 2	[illegible]	525
Nut food+Cor Trumilk 6 oz	0 11	1 81	27 20	54 14	81 01	948
Trumilk ½ oz	0 06	0 41	1 74	1 00	2 90	15
Total 11½ oz	.1 97	5 7	75 00	60 18	156 18	1 508
SUPPER						
Oatmeal 2 oz	4 01	0 88	12 04	5 44	31 02	[illegible]
Lard 4 ⅘ oz				127 57		1 187
Sugar ½ oz					14 17	58
Beef powder 1⅓ oz	0 96	3 8.	1 20	2 17		166
Glidine ⅘ oz	1 28	0 08	11 78	0 14	0 82	53
Biscuits 1 oz	1 52	0 30	9 21	0 87	10 85	105
Trumilk 1 oz	0 11	1 66	6 70	8 00	11 58	150
Sugar additional lump ½ oz					14 17	58
Total 11 ⅙ oz	9 95	6 7	75 9	144 27	126 [illegible]	2 119

Meat extract ½ ounce issued with supper ration.
Tea ... issued with lunch ration.
Lime juice ⅘ ounce. Cerebos salt 1 8 ounce daily.
Total Calories per day=... 12
Total fat per day=320 58 grammes.
Total protein per day=226 13 grammes.
Total carbohydrates per day=400 28 grammes.

The Largest Centrifugal Pump

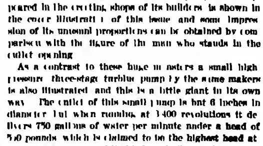
Modern engineering enterprises are, wherever possible, conducted on a gigantic scale, for it has been found here, as in business, that doing things by wholesale is cheaper than retail methods. A recent case illustrating this occurred in New Orleans, where very large quantities of water had to be handled in drainage work, and to meet the requirements four immense centrifugal pumps were ordered, which are said to be the largest of their kind in the world.

These big pumps have a delivery opening of 78 inches diameter, and are capable of delivering 168,000 gallons of water per minute at a one foot head, which is equal to the flow of a good sized stream. The head of water will vary under different working conditions from one to thirteen feet, and at this latter difference of level 90,000 gallons per minute can be handled, but the pumps are required to turn up much faster than at low lifts, for whereas they do their work at 55 revolutions per minute when the head is but one foot, it requires 113 revolutions to move the stated amount at the 13 foot head. This, however, is by no means excessive, and the pumps will be very economically operated by Nordberg Corliss compound condensing engines.

Besides these monsters there will be a fifth pump in the outfit which has an outlet of 48 inches and a capacity of 47,500 gallons per minute at 3 foot head, as against 150,000 gallons at the corresponding lift by its big brothers. These pumps are built by the Southwark Foundry and Machine Company of Philadelphia.

A picture of one of the big 78-inch pumps as it appeared in the erecting shops of its builders is shown in the cover illustration of this issue, and some impression of its unusual proportions can be obtained by comparison with the figure of the man who stands in the outlet opening.

As a contrast to these huge monsters a small high pressure three-stage turbine pump by the same makers is also illustrated, and this is a little giant in its own way. The outlet of this small pump is but 6 inches in diameter, but when running at 1,400 revolutions it delivers 750 gallons of water per minute under a head of 540 pounds, which is claimed to be the highest head attained by any pump of its kind yet built in this country.



The little giant high-pressure pump.

Maps and Map Making*

An Historical Review of the Development of the Art of Topography

By Sir Thomas H. Holdich

A SAVAGE often possesses the instinct of rudimentary map-making; that is to say, he has the fundamental instinct in him which certain animals (I might say all wild animals) have for direction. I remember once searching for an old and disused salt cave on the Persian coast which was said to be inhabited by devils and other unpleasant inhabitants and which possessed extraordinary subterranean scenery of great wonder and beauty. It was a very hot and a very weary quest. We should, I think, have abandoned the search among the low hills which crowded down to the shore line but that we observed a ragged and scantily clothed individual sitting in solitude on the shore with a suspicious lump of something before him which he was guarding carefully. The practised eye of my companion observed a native craft on the blue horizon which he rightly conjectured to be engaged in illicit salt traffic, and we at once found a way out of our trouble. The man on the shore could speak no word of dialect that either of us knew and we could only point helplessly to the lump of salt and to the hills and insinuate by means of certain coins that we were not there to interfere with him; we only wanted to see where that salt came from. So with his fingers he drew a map in the sand and he did it so well that half an hour's climbing led us into the narrow mouth of the cave and we saw there what I believe no other European had ever seen.

The point of the story lies in the fact that precisely the same symbolism, the alphabet of map-making, came as naturally to the hand of that smuggler as it has to the hand of all map-makers since the days of Ptolemy till now. The very earliest maps of which there is any record are those of Claudius Ptolemaeus which were made about 100 to 150 A.D., but the earliest copies of them to which we can refer did not exist till about the year 1400, thirteen centuries after they were actually compiled.

But there were other maps during the thirteen centuries which elapsed between the making and the publishing of Ptolemy's maps and some of them are remarkably interesting. St. Jerome's translation of the Greek work Onomasticon A.D. 388 deals with Biblical countries. A famous map of the world was compiled by a Spanish monk St. Beatus in A.D. 776. This makes the earth square, plants the Garden of Eden at the top of the map (which is the eastern side of it) with Eve and the serpent in orthodox relationship. The next important map is the Cotton or Anglo-Saxon map of the world dating from about the end of the tenth century. Here Jerusalem is no longer the center and Taprobana or Ceylon is at the top. A map dating from 1200 again places Jerusalem in the center but from the Garden of Eden at the top there flow out five rivers, the Ganges being included. This is a diminutive map designed to illustrate a psalter but room is found in it for a great variety of human monstrosities such as are common to all mediaeval maps. These remarkable additions to mediaeval mapping are really interesting as indications of the nature of the ethnographical knowledge of the time. It is quite probable that they represent the prevailing ideas of the educated [illegible] regarding the strange living world beyond their immediate ken. About the year 1350 and for a century later there was a popular history in England written by a monk of Chester called the Polychronicon and in it there are two maps compiled in the conventional style of the day, full of Biblical legends and popular myths.

Coupled with much information of ethnological interest about men with one eye or with hairy bodies we find these curious facts stated for the enlightenment of posterity. Germany it is said has a greater population than it is able to feed, while Ireland is both larger and wider than England. It seeks liberty but *shirks work*. One of the latest of the mediaeval manuscript maps in the British Museum is a copy of a map compiled in 1460 by Fra Mauro. Its geography, says Mr. Villiers, shows an immense improvement on the last map of 1350, Europe being especially good.

Of the collected printed maps just one or two require a short reference. There is the map known as the Cusa map compiled before 1464 which is printed from a copper plate by Cardinal Nicolas of Kusean which was the chief map of its time, and a map of the world in the *Insularium Illustratum* of Henricus Martellus Germanus is to be noted as the first showing Portuguese discoveries. At this point in map history commence the first rudiments of modern cartography. A Dutch printed map by Johannes Ruysch first represents India as a peninsula. That was in 1507, and it indicates the gradual progress of geographical knowledge. The Waldseemuller map of about the same date introduces the New World and further defines Portuguese discoveries; and yet another Dutch map (for the Dutch may claim to be pioneers in this branch of the art of printing) usually known as Jan Severszen's map, which undoubtedly is much indebted to the Waldseemuller map for its material, is quite a good example of early topographical art. The mountains now assume the appearance of lines of haycocks, and the trees indicating forests are all of the pointed Noah's Ark variety. Strange beasts, including an enormous elephant, stray over the continents and monsters of the deep indicate the perils of the sea. Thenceforward the gradual evolution of the printed map passed into the hands of Italians who took a much stronger lead in geographical illustration than in geographical discovery. Gerard Mercator at the end of the sixteenth century was the great map maker of his day and his projection (notable perhaps, for its simplicity) is in use at the present time. Mercator gives us by far the best map of Ireland yet produced.

It is to be regretted that the greatest geographers of the mediaeval ages (the Arabs) have left so little in the shape of cartographical illustration behind them.

There is no doubt a feature common to all these old-world maps which cannot be admitted now, but the old world endeavor to unite ethnographical knowledge to that of more prosaic geography is no longer considered admissible. In fact, it is the extraordinary wealth of an infinite variety of information conveyed by legend and by pictorial illustration which renders the old form of mapping so interesting and so confusing. There are indeed certain details which may be considered as historically useful. We learn something of what our forefathers knew about the world they lived in. We learn what their shipping was like, even if we cannot admit their sea-born monstrosities. We have found that in some details of geographical information they possessed a knowledge of facts which have been discarded since their time only to be revived again as correct in modern days, as for instance in the case of the Nile sources and the mountains of Central Africa.

With the gradual evolution of a system of cartography which should first of all divide land spaces from water by outlining the continents and islands of the world and thereafter separate mountain systems from plains and secure some representation of the hydrography of the earth by delineating the course of a great rivers, there arose the imperative necessity for a form of projection of the map, the definition of parallels of latitude and meridians of longitude by means of which the true relationship of separate areas of the earth could be correctly maintained. Obviously this necessitated careful measurement of the earth's surface in order to determine its figure and to establish laws and formulæ whereby these parallels and meridians could be laid down accurately previous to the introduction of topography. Thus arose the science of geodesy or earth measurement.

It cannot be too strongly insisted on that all sound map-making must be based on sound geodetic measurement in the first instance. To put it shortly: Triangulation, which is the outcome of geodesy, is called upon to supply the framework or skeleton onto which the topography or the body of the map has to be filled. This framework is furnished with a projected graticule system (i. e. with lines of latitude and longitude correctly defined) so that the picture or plan of the country in question can be carefully adjusted by means of the points fixed by the triangulation, which are, of course, common to both the geodetic projection and the topographical map. This adjustment is the work of the cartographer. Sometimes, as in India, the cartographer and the actual topographical surveyor in the field are one and the same person. Sometimes, as in Russia, a highly practised cartographical artist is employed to take the field sheets from the hand of the topographer and translate them to the finished map without reference to the surveyor at all. It is this latter method, doubtless, which produces the most artistic effects, but it should be remembered that topography is not only an art but a twofold art. There is the cartographic art of translating the field map to the final sheet for publication, and there is the art, only really given to few, of representing Nature on the field-map as she actually exists. The art of the topographer thus combines that of the painter and the engraver.

I need hardly say that when I talk of making map pictures from Nature I am talking of the plane-table method of making them. It is the one process which fully deserves the appellation of art, and the beauty and advantage of this system of map-making is that it appeals to the highest artistic instincts. I do not mean that an inartistic effort may be inaccurate or useless.

If accuracy is our object, then no professional cartographer, however gifted with artistic imagination and draftsman's skill, can take the place of the man who sees and knows, into whose eyes the picture of great world-spaces has entered. Unfortunately, gifts of imagination combined with draftsman's skill often make very pretty showing. Experience will enable a clever cartographer, a draftsman who has never been in the field, to represent even complicated topographical features of an imaginary character with a skill such that even an experienced surveyor can hardly detect the lies in it, and so it comes about that if a map is to be judged by its accuracy and faithfulness to Nature, apart from artistic effect, it is very often the most unattractive maps that are the best. Please remember this, and remember also that the processes of reproduction vary infinitely, and that when you look at a really beautiful production, full of harmonious light and shade and delicate indications of graceful features where effect requires them, and exclaim "What a lovely map!" you may be merely the innocent victim of a skilful cartographer who has been backed up and perfected by a first-rate publisher.

It is interesting to observe the slow but gradual development of the art of topography from the earliest maps until now. The alphabet of the process has remained much the same. Mountains and plains, rivers and coast lines have been simplified and perfected so as to produce the most readable map, but the alphabet has not fundamentally altered. It is in the matter of relief chiefly that the change is noticeable. The earliest attempts at depicting mountains by pictorial elevation have given place to plan. The little groups of conical excrescences, like bands of haycocks, were by no means unintelligible, though purely conventional. Indeed, it may be doubted whether to some intelligences they are not even now a more effective illustration of hilly country than our latest and most scientific system of contouring. Between the two we may find every variety of method employed which can produce the effect required. In large scale maps dealing with comparatively small areas and involving no great differentiation in altitude it has long been decided that the only scientific method of depicting the country is by lines of contours (i. e. line of equal level) at definite vertical intervals. It undoubtedly has its drawbacks. There may even be a difficulty here and there in the distinguishing between an elevation or a depression unless the value of the contours above the datum are distinctly stated in figures. But it is beyond dispute that for all military or fiscal purposes the contoured map is the only one admissible.

Difficulties arise when the elevations on the face of the map rise from the status of hills to that of mountains, and with the gradual steepening of slopes the delineation of contours gets closer and closer until it is impossible to introduce them on small scale maps without overlap and confusion. This applies to the many forms of geographical maps from the scale of one inch to the mile downward, when it usually happens that some more artificial and less conventional method of illustrating mountains in plan is necessary. The difficulty is usually met by "hachuring," that is to say, by introducing broken instead of continuous contours, and abandoning regularity of vertical interval. It is here that the artist steps in.

The weakest link in that chain of processes which is the basis of scientific map-making lies in the process of combining new work with old. People ignorant of the processes of map-making can have little idea how much the process of revision enters into the matter. The rapidity with which fresh artificial topography, in the shape of roads, railways, houses, etc., springs into existence, combined with the action of wind and weather in changing the face of Nature, [illegible] all the resources of the Ordnance Survey to keep pace with it. And it is almost impossible to maintain a high standard of up-to-date mapping, which is [illegible] in any one map [illegible] of any size, [illegible] it. But when we come to the [illegible]

* Extracts from inaugural address before the Royal Society of Arts.

we include under the term geographical, i e, wide areas depicted topographically on small scales within the rigid lines of a restricted sheet, these variations in quality of accuracy become far more pronounced and more important. No one but the compiler (who keeps the record) can possibly say what is the exact value of any one portion of the map, how far it is to be trusted in the business of conducting military affairs or the international arrangement of boundary settlements

A naive belief in the accuracy of a printed map compilation has foundered many a high political programme, even when the geographical features which may form the basis for a treaty have already been correctly shown as they existed at the time the map was made. The face of the earth changes and locally changes very fast.

No need to elaborate this propensity of our earth world to change its face or of its more primitive inhabitants to change their habitations and call them perpetually by new names I only refer to it as a caution to map critics.

I have said a word or two indicating that the gift of imagination must still have its place in map making This may sound almost immoral although it is but a page from past records, and yet I have come to the conclusion that if the public is asked to exercise imagination in reading the map the map-maker must meet the public half way It is still, of course in the domain of geographical mapping where the conformation of the ground is partly well known partly indifferently known that imagination must here and there be called upon to supplement actual knowledge If the map-maker were to confine himself to absolutely what he knew to be true in the delineation of mountain and valley or of rough desert areas wherein no living creature moved he would simply leave large white blanks in his map which might in themselves be most misleading

It used to be the fashion to leave such blanks but in my opinion it is better to introduce mountains or deserts where they are known to exist to indicate all that can be seen from a distance than to make no sign at all The part of the map which is conjectural should of course be carefully indicated but there is doubtless a tendency on the part of enthusiastic explorers to consider much of these conjectures as certainty and to make no specific distinctions between what they know and what they think they know In this way it often happens that succeeding explorers in the same region are apt to condemn the work of their predecessors from want of knowledge of the exact nature of the different parts of that work

I may say just a word here about map criticism It is a most common thing for even intelligent travelers passing over a country with a map in their hands to report that they found the map all wrong Now in the case of expeditions into partially known lands it is only the expert who can say whether the criticism is a just one or not It must cease, it is not for the simple reason that ordinary travelers have no means of identifying their position and do not know exactly where they stand while as regards place names although they may succeed in identifying the position named they are at the mercy of native guides and interpreters for their own information

There is one matter about which experts disagree more or less and it is one on which I think the public might well express an opinion It is the fashion now to indicate successive planes of elevation by flat tint and the ordinary application of color for that purpose is in shades of green for the lower elevations rising into brown which deepens with the altitude So well known is this system that I think it may be considered to have established a fair claim to permanence so far as British maps are concerned For my own part I can imagine nothing better for ordinary touring maps But difficulties arise when the altitudes are great rising to many thousands of feet as in mountainous regions Here it is admitted that no one universal system of color printing is satisfactory This is not an unimportant matter for it directly affects geographical education which now is so largely assisted in schools by wall maps In the effective preparation of these we want the opinion of both teachers and of artists

Astronomy in the Arctic*

Some of the Duties and Hardships of Observers in the Frigid North

By Russell W Porter

Some twenty years ago it was the fortune of the writer—or misfortune, rather—to become inoculated with the virus of that strange 'wanderlust known as the 'Arctic fever" Since that time he has taken ten voyages above the circle The following notes on the part of his labors bearing on the astronomical problems arising in the extreme North may be of interest to amateur observers who have never strayed so far afield

The duties of the astronomer of a polar expedition are the determinations of the latitude and longitude of the winter quarters and Greenwich time There are other activities, such as the mapping of any new lands observations in connection with magnetic work etc but the first-mentioned are the most important, particularly a knowledge of the Greenwich time—for, as we all know, the meridians of longitude converge at the Pole to a point, and the longitude is the difference between local and Greenwich time Therefore it is quite necessary that a person traveling toward the Pole over a shifting sea of ice should know upon what meridian he is journeying, and that on his return from the Pole he should know upon which of the meridians he is descending, in order to arrive safely at his base of supplies The compass due to its weak horizontal component is too unreliable a guide

The Greenwich time is transported from civilization to the winter quarters by means of chronometers on the ship. Were their rate of gain or loss uniform this method would be sufficient But the shock of the ship in forcing a passage through the ice is very great and the clocks change their rates, so that, arriving at winter quarters after a summer's battering through ice floes, a knowledge of the time at Greenwich is very poor and not to be depended on So recourse is had to other and absolute methods—either by occultations of stars by the moon, or moon star culminations From either of these observations the center of the moon is determined in right ascension at a certain instant of local time and by entering an almanac and finding what the Greenwich time is when the moon has this right ascension and by taking the difference between these two times the longitude is at once obtained The degree of accuracy so found is not great, but it must be remembered that a degree of longitude near the pole is a very much smaller quantity than at the equator, so that, for practical purposes, quite a large error is admissible

On the writer's last Polar expedition, an observatory was erected on a basalt ledge one hundred yards from the house. It was about 7 feet square, with walls of matched sheathing, north and south shutters, and a shutter in the flat and slightly inclined roof A transit instrument by Heppold with 12-inch circles reading to single seconds of arc was set up on a brick pier The chronometers at the house were never disturbed Beats from the adjacent break-circuit clock were heard by means of a sounder on the wall of the observatory A collimating pier a few feet north of the transit served for the north meridian mark while a signal made of several biscuit tins one on another placed on a glacier a few miles away, served as a south meridian mark By swinging the instrument out of the meridian and sighting through a hole in the wall the magnetometer of the magnetic observatory some thousand feet away could be seen and thus all magnetic declinations referred to the primary meridian

The writer spent many long hours in the observatory through the winter night with his eye to the telescope watching the tiny star disks passing across the seven vertical threads of the reticule Dressed in heavy furs with one hand bare to record the time intervals he was obliged to sit motionless for sometimes two or three hours at temperatures ranging from 30 degrees to 60 degrees below zero with no artificial heat and the bitter wind passing freely through the building At times the room would suddenly fill with a fog so thick as to require an immediate cessation of work Often the oil in the illuminating lamp hardened to the consistency of slush and the lamp refused to burn Tiny ice particles of hoar frost were very bothersome settling on the pivots of the transit and throwing the horizontal axis out of level There was no running around the block stamping the feet, or swinging the arms to restore circulation—just a steady nerve-racking watch

Those observing at the magnetic hut fared no better Here the vagaries of the needle were watched and recorded every two minutes over an unbroken interval of nearly two years

The peculiar conditions surrounding the pole present other obstacles The sun never mounting high in the heavens is weak in actinic rays hence the photographer has his troubles In using an artificial horizon with a sextant the small angle of incidence prevents the whole disk of the sun from being observed In fact the small transit instrument is altogether preferable to the sextant in polar work Those made especially for the Ziegler polar expedition were but little heavier than the sextant and mercury basin and far more useful

During the long summer's day of four months the writer has tried to find the moon but has never succeeded The heavens are not blue but a bright, glaring grey due to the reflection of the sunlight from the surface of the snow It very effectually "puts the moon out of business," as far as the astronomer is concerned On the other hand, in the winter night the moon is above the horizon continually through half of each lunation, and has much the same appearance as in lower latitudes.

Imagine yourself at the pole, with the meridians of longitude radiating out from your feet until they disappear over the rim of the horizon It is about June 21st, the summer solstice, and the sun is revolving around the heavens at an altitude of some 23 degrees, as ever just once in twenty four hours but neither rising nor descending in its path through the sky What time is it for you as you stand there—that is time as understood by an astronomer? The answer is easy there is no local time It is equally true to say that it is all hours Now step off the pole toward the sun wherever it may happen to be You are now on the meridian over which the sun is situated It is noon to you astronomical noon Take two steps backward you have crossed the pole are on the same meridian and it is astronomical midnight In this manner you can make the time of day anything you choose by simply taking one step away from the pole in the direction of the meridian on which that particular time obtains

If you could afford to remain at this unique spot throughout a year you would see the sun start on a slowly descending spiral until at the autumnal equinox he would be rolling around the horizon like a big billiard ball The next day he would show only his top edge and the next would disappear entirely for six months slowly spiraling downward until at the winter solstice he is 23 degrees below the horizon and begins his slow return In March he again puts in an appearance repeating his performance of the fall before but in reverse order until on June 21st he is at his highest These would be the phenomena provided you could see them but the chances are that there would be but fugitive glimpses now and then as the snow is drifting almost continually in high latitudes

The auroral displays are of course of common occurrence beyond the circle and at times in the winter become so brilliant as to lighten up the "snowscape like full moonlight In Franz Josef Land and north of Russia the streamers predominate the auroral arch not being common but in the vicinity of the north magnetic pole the arch is seen more often The writer has never been able to hear the peculiar sound resembling rustling silk so often spoken of by Arctic explorers as accompanying a brilliant display And it is his impression that the great magnetic disturbances as observed in the magnetometer in winter are not necessarily accompanied by exceptionally bright aurorae

* Paper or address delivered before the First International Convention of the Society for Practical Astronomy, Fort Clyde, Alaska.

Where Timber is Wasted

It will surprise most people to learn that boxmakers in the United States use more than four and a half billion board feet of lumber each year or more than one tenth of the entire lumber cut of the country This is the authoritative statement made by the Forest Service of the Department of Agriculture and although most of these boxes are used several times still it is suggestive of a very considerable portion of our fast disappearing forests Already the high price of suitable lumber is forcing manufacturers to seek other materials and more economical methods for packing and shipping their goods, but there is room for much greater developments in this direction

Over the ocean by rail.

To Cuba by Rail

The Last Link Between Key West and Havana Joined

By Harry Chapin Plummer

To Cuba by rail! The dream so cherished by Henry M. Flagler, the founder of the Florida East Coast Railway system, has found its ultimate realization in a wonderful car ferry steamer stated to be the largest and most capacious of her type in the world. This powerful craft which bears Flagler's name and which is designed specially for the 100 mile run between Key West, Fla., and Havana, Cuba, will complete the final link in the passage of freight without trans-shipment between the cities of the United States and Havana, Santiago and interior points on the island of Cuba.

At the Havana terminus of the ferry the steamer effects a track connection with the United Railways of Cuba which, like the trackage aboard the ferry steamer and that of the Florida East Coast Railway, are of standard gage.

Map of the Florida Havana route

In their journey from the north to Key West, trains pass over the $15,000,000 viaduct system that bridges the 107 miles of alternating stretches of water and coral islets lying between the mainland of Florida and Key West. The car ferry steamer Henry M. Flagler, which goes into service next month, will fill the last gap in the journey to Havana and so fulfill the purpose of the builder of the wonderful chain of viaducts.

It is in the movement northward from Cuba of grape-fruit, oranges, bananas, pineapples and other products of the "Pearl of the Antilles," which are liable to the greatest danger of ruin or injury when transfers are made, that the new vessel must prove her worth at the outset. On her southward runs from Key West she will move trains largely laden with dressed beef and foodstuffs originating in the West and the North of this country.

Equipped with four sets of tracks of standard gage on the car deck, which is 360 feet long and provides accommodation for thirty of the largest size refrigerator cars, the ferry-steamer is, in addition, fitted with three cargo holds. These can be loaded either direct from the cars or through cargo ports at the side of the vessel.

The dry cargo capacity of the boat is approximately 1000 tons, with an additional provision in one of the forward ballast tanks for the shipment of a bulk quantity of molasses. Each cargo hold is served by an independent double drum electric cargo hoist of two tons capacity, and the necessary filling and discharging apparatus has been fitted to the tank intended for molasses.

Ten water-tight compartments into which the vessel is sub-divided are used for ballast purposes. These deep tanks have a capacity of 3000 tons, and the steamer thereby can be brought down to her proper draft when no cargo is carried. A system of pipes connects the tanks, and for emptying them two 12-inch centrifugal pumps have been fitted which have a capacity capable of clearing all the tanks within an hour and a quarter.

Two triple-expansion engines of the usual marine type, having cylinders 20, 32½, 54 inches diameter by 36 inches stroke, compose the power plant of the vessel, each developing 1,500 indicated horse power at 100 revolutions per minute when operating under 170 pounds steam pressure. The voyage of 100 miles (from dock to dock) is to be made in eight hours—at an average speed of 12½ miles per hour.

The boiler plant will consist of a battery of four Scotch type boilers, each 13 feet 2 inches in diameter by 12 feet long and each fitted with two 48 inch Morrison corrugated steel furnaces. The boilers will be operated under the Howden system of forced draft and they are built for a working pressure of 170 pounds. The auxiliaries are more than ordinarily complete, the feed circulating and ballast pumps being duplicated, as is also the electric plant.

A notable feature of the boat is the fine accommodations provided for the officers and crew. Four individual baths are provided for the officers, while the crew's quarters are equipped with four shower baths. Running hot and cold water is furnished for each room, and cold salt water for the shower and bath tubs.

The steamer, the keel of which was laid April 20th last, was built at the Cramp Shipbuilding Yards, Philadelphia, and launched September 22nd. M. O. Furstenau, consulting naval architect for the Florida East Coast Railway, designed the plans and specifications.

The idea of quick communication with Cuba is not new, for the promoters of the Florida East Coast Railway have had it in view for many years, but the accomplishment has been slow on account of the many difficulties to be overcome. It was no small undertaking to extend the line down the sandy marshy shore of Florida to Miami, where a long pause was made. Then came that daring engineering feat of carrying a railroad over the swampy tip of Florida and thence by a remarkable series of embankments and concrete viaducts, using the long curving series of keys as stepping stones, to Key West, the outermost accessible point that can be reached in this manner.

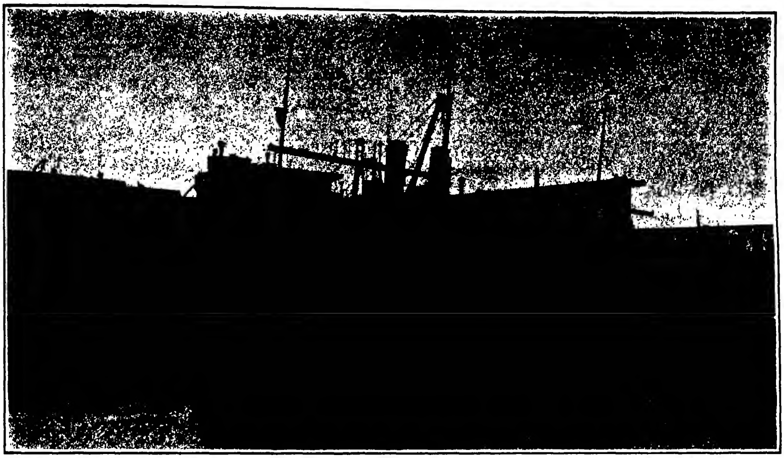
In building this wonderful viaduct, which is 128 miles long from Homestead at the tip of Florida to Key West, earth and rock embankments were used wherever the depth of the water permitted, and over fifty miles of this kind of roadbed was constructed, but in many of the intervals between the keys, of which about thirty were linked together by the undertaking, the water was too deep to permit of filling in, and moreover many of these openings were navigable passages that could not be closed or were in such exposed positions that embankments would not stand. Here a series of massive reinforced concrete viaducts were placed, being built with arches of 50 or 60 feet spans. Altogether these viaducts have a total length of somewhat over five and three fourth miles, there being four separate viaducts running from 4,950 to 10,500 feet in length.

At the time the road reached Key West it built a substantial drydock, together with ample wharves, so that it was all ready when the time came to establish the hundred mile ferry to Havana, as has now been done.

Electrolytic Silver-cleaning Method

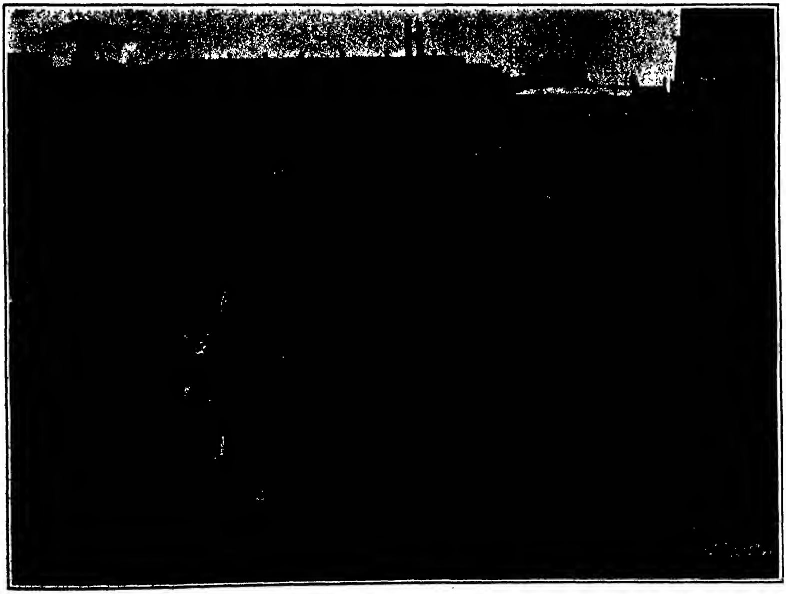
This is an original method which is the object of a French patent. Instead of cleaning solid silver or plated objects by the usual powder polishing, which, of course, has a bad effect on the surface, such objects are simply put in a non-metallic basin (enameled ware or the like) and are cleaned by electrolytic action alone. This is done by putting on the bottom of the basin an electro plate of specially prepared metal, the bath being a solution of carbonate of soda. From three to five minutes in the bath is all that is needed in order to remove all oxidation from the surface of the silver objects, then rinsing and drying. According to a statement by the Paris Municipal Laboratory there can be no deterioration of the objects by this process.

The viaduct that links Florida to Key West.



The car-ferry steamship that transports trains from Key West to Havana.

The trip from Havana to Key West will be made in eight hours, and perishable cargoes, such as oranges, bananas, and pineapples, loaded in cars, will be sent through to any American city without trans-shipment or handling.



Building the great Key West-Cuba car-ferry steamship. Showing the opening in the stern where the trains are run on board.

Four tracks for trains are laid on the main deck, and besides carrying thirty of the largest refrigerator cars, the vessel can carry a large quantity of molasses in bulk in her tanks, as well as much freight.

Apparatus for Demonstrating Newton's Laws

Studying Motion Accelerated Under the Action of a Constant Force

By H. W. Harmon, Grove City College, Grove City, Pa.

Most of the standard text-books in physics and mechanics, under the topic of Newton's Second Law of Motion, give more or less space to the discussion and solution of problems concerning the tensions in cords attached to accelerated bodies, using the cables attached to rapidly ascending and descending elevators for their illustration.

Several years ago it seemed desirable to design an apparatus suitable for our students in the physical laboratory, to test out these principles experimentally. The difficulty met with at once was to find a practical method of measuring these tensions while the bodies were in such rapid motion. Finally, the apparatus shown in the diagram was developed and has been in use by our students for the last two or three years.

As inertia, acceleration, changes of momentum, and reaction are all involved in the experiment, it goes with us under the name of the Newton's Laws Experiment.

Referring to the diagram, Figs. 1 and 2 show a top and front view of the apparatus. The body to be accelerated is a car shown in Figs. 3 and 4, arranged to be variously loaded. It slides over the surface of a hard wood box about 18 feet long and 2-inch by 4-inch section. The car is released from its starting position by the action of the electromagnet (H) shown in Fig. 3, and operated by the clock pendulum, Fig. 2, making and breaking contact. The car is accelerated by the unbalanced weight of the mass M_1, which may also accelerate M_2 if it is attached to the rear of the car, as shown in Fig. 2. The cord connecting the car and M_1 passes over a frictionless pulley mounted on the movable arm shown in Fig. 5. It is apparent by a glance at the spring balance (B) in Fig. 2, that the tension (T_1) in the cord connecting M_1 and the car will be registered by balance B, if allowance be made for the weight of the arm and a slight leverage action of the pulley itself. By this simple scheme we were enabled to measure the tensions in the cord attached to the accelerated body regardless of the high velocities attained.

A curve card is plotted in which the weight of the arm and the leverage of the pulley is allowed for, and by its use, balance readings can be taken off from the curve as true tensions (T_1).

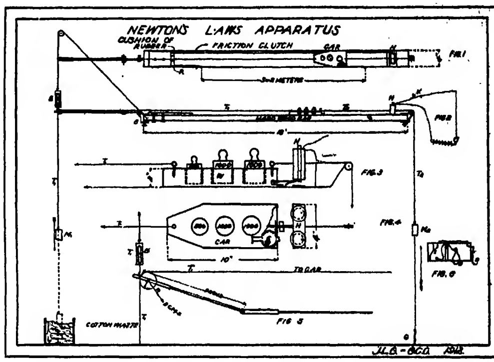
This balance correction is made as follows: With the pulley arm in the horizontal position and the tension T_1 zero, the balance was found to read 125 grammes, owing to the weight of the arm. This weight is included in all cases in the reading of B. But more or less completely neutralizing this weight of the pulley arm is an upward component of the tension ($= 2/32\ T_1$), for as used in this position the pulley, the pulley wheel and arm constitute a right-angled, bent arm lever with power arm equal to the radius of the pulley (2 centimeters), and the weight arm equal to the length of the pulley arm (32 centimeters). With this correction for the weight of the beam, the equation connecting the balance reading B with the tension T_1 will then be:

$$B = 125 + T_1 - \tfrac{1}{16} T_1.$$

To draw the correction curve, remember that when $T_1 = 0$, then $B = 125$ grammes; when $T_1 = 125g$, $B = T_1 = 2{,}000$ grammes. Locate these two points on a sheet of cross-section paper by the usual method and draw a straight line through them. (See balance correction curve diagram, Fig. 2.)

To keep the car on the track, the bar has a half round groove formed in it through its entire length, and a corresponding half round runner is fastened to the bottom of the car. To keep the friction constant, the sliding surfaces are kept uniformly polished and oiled with heavy oil. The high velocities attained, 5 meters per second or more in some trials, are reduced without too much shock by the friction clutch and rubber cushion shown in Fig. 1. The velocity of M_2, when attached, is reduced to zero by a spring or gum tube (G) attached to a trailing cord which goes into operation at the same time the friction clutch does on the car, while M_1 is brought to rest in the box of cotton waste shown in Fig. 2.

When the apparatus was first put into practical use the car was released by a trigger operated by hand and the timing done with a stop-watch. Thus operated, the errors due to timing gave results in which the percentage of error was in some trials quite large. Recently we have mounted on the car an electromagnet (H) shown in Fig. 4, which is arranged in series with the releasing electromagnet (H). The armature of this magnet, pivoted to move up and down, has a spring brass wire soldered to it, extending over the back end of the car and bent down near the surface of the sliding track, where it terminates in a piece of chamois skin moistened with well thinned printer's ink. This is shown in Fig. 6 by I. The electric current is led to the car by two wires, one stretched taut down the back side of the bar; the second one is stretched down a second half round groove in the top of the bar. Contact brushes BB for these are shown in Fig. 6. The inker marks off on the bar distances covered in even seconds as beaten off by the seconds pendulum of the laboratory clock. The slotted weights which go to make up M_1 are so chosen that the unbalanced force in the various trials of the experiment causes the car to make its run down to the clutch in just slightly over 2 seconds.



The inker operates very accurately, for, even in those trials in which the car is traveling 500 centimeters per second, successive trials seldom differ by more than two or three centimeters in the total distance covered in the 2 seconds' time of run used. This indicates that the combined error of the inker and release magnet does not exceed 1/200th of a second in the timing. Since equipped with this improved timing device, the apparatus has given very satisfactory results, as can be seen by an examination of the data table. The errors remaining are almost entirely due to balance readings and friction measurements.

The friction is found for each trial as the car is differently loaded. This is done by placing on the weight support, M_1, such slotted weights as will cause the car, when started, to move down the track with a slow uniform motion. In those trials when M_2 is attached to the rear of the car, the total of the slotted weights thus needed, less the weight of M_2, is called the friction.

METHOD AND THEORY OF EXPERIMENT.

First clean, oil and polish the sliding surfaces, then load the car as required and find the friction (F_f) as above. The required weights are next placed on the M_1 weight holder and the car placed at its starting position and held by the trigger ready to be released, following the closing of the electric switch (k) in the clock circuit. When the car is released and is speeding down the track toward the friction clutch, one observer watches the index of balance B, and takes its reading. This is usually repeated three times, and the average reading of B is taken, corrected by reference to the curve card and recorded as T_1.

At the same time, for each of these runs, the distance the car has traveled in 2 seconds, as marked off by the inker, is measured, and these distances averaged ($= S$).

The unbalanced force (F_a), which causes the car and attached masses to be accelerated as it runs down the track, is the difference between the weight of M_1 and the friction (F_f) and also less M_2 if it is attached.

Newton's second law enables us to compute what this acceleration a will be. If absolute units are used, the equation is

$$F_a = Ma,$$

or, using the gramme-weight as the unit of force, and the gramme as the unit of mass,

$$F_a = \frac{Ma}{980}$$

where F_a is the unbalanced force, M is the total mass accelerated, and a the acceleration.

In our present problem the total mass M is given by

$$M = M_1 + M_2 + W,$$

where W is the mass of the car and load. The acceleration a as computed by the formula

$$a = \frac{980F_a}{M} = \frac{980F_a}{M_1 + M_2 + W}$$

(F_a being measured in grammes weight) should agree with a computed from

$$s = \frac{1}{2}at^2$$

$$a = \frac{2s}{t^2}$$

The tension T_1 in the cord connecting M_1 and W is equal to the sum of the frictional force F_f (measured in grammes weight) of the weight 980 M_2 of the mass M_2, if attached, and of the unbalanced accelerating force

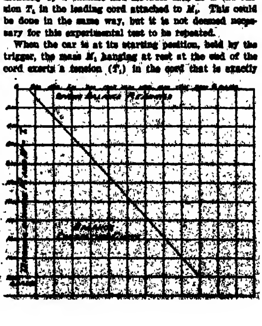
$$F_a = \frac{(W + M_2)a}{980} \text{ grams. weight acting on } W \text{ and } M_2.$$

$$\text{Thus } T_1 = F_f + M_2 + \frac{(W + M_2)a}{980}$$

This should agree with the corrected balance reading T_1.

It will be noticed that the tension T_2 in the cord connecting the car with the mass M_2 is not observed experimentally by a balance and movable arm as is the tension T_1 in the leading cord attached to M_1. This could be done in the same way, but it is not deemed necessary for this experimental test to be repeated.

When the car is at its starting position, held by the trigger, the mass M_1 hanging at rest at the end of the cord exerts a tension (T_1) in the cord that is exactly



equal to its weight. The weight of M_1 at rest is fully effective in producing tension. A freely falling body has no effective weight, for its weight force is all used in accelerating it. A falling body only slightly accelerated has a proportional part of its weight effective (i. e., a man in a descending elevator). This effective weight approaches zero as (a) approaches (g) in value when (g) equals an acceleration of 980 centimeters per second per second, or 32.16 feet per second per second; and the weight of a body approaches full effectiveness as (a) approaches zero. We shall therefore expect to find the values of T_1 always less than M_1, and T_2 always greater than M_2, for M_2 is accelerated upward, and T_2 consists of both the weight of M_2 and the force which is accelerating M_2. Reference to the data table shows those expectations realized.

In looking into the factors which enter into this experiment, inertia, momentum, impulse, friction, and tension, it is seen that Newton's Three Laws are all fully involved, and also the laws of accelerated motion. A knowledge of most of the terms used in mechanics is necessary. This therefore should make an especially effective experiment for the junior student in physics or the student making a special study in mechanics.

No.	Masses: + Mass M_1	Masses: Load W	Masses: — Mass M_2	Friction F_f	Coefficient of Friction $F_f \div W = C$	Space S	Time t	Acceleration: Observed $\frac{2s}{t^2} = A$	Acceleration: Computed $= \frac{980 F_a}{W+M_1+M_2} = A'$	Error	Tension between M_1 and W: Observed T_1	Tension between M_1 and W: Computed $F_f+F_a+M_2 = T_1$	Error	Tension between W and M_2: $= M_2+F_a'' = T_2$	Unbalanced Accelerating Force On: M_1+M_2+W: $M_1-(M_2+F_f) = F_a$	Unbalanced Accelerating Force On: W+M: $\frac{(W+M_2)a}{980} = F_a'$	Unbalanced Accelerating Force On: M_2: $\frac{M_2 a}{980} = F_a''$
	grms.	grms.	grms.	grms. weight		cm.	secs.	cms. per sec.	cms. per sec.	%	grms. weight	grms. weight	%	grms. weight	grms.	grms.	grms.
1	1,865	3,160	0	860	.272	391.0	2.0	195.5	195.6	0.0	1,440	1,491	3.4	....	1,005	631	.....
2	1,865	2,360	0	655	.278	370	2.0	185.	186 7	1 7	1,070	1,101	2 9	....	710	446	....
3	1,115	1,860	0	500	.269	394.5	2.0	197.25	202.3	2.7	855	874	2.2	....	615	374	....
4	700	1,080	0	305	.283	422 1	2.0	211.	220	4.4	538	532	0 9	....	395	228	....
5	1,865	660	1,000	270	.409	371	2.0	185.5	187.7	1.2	1,555	1,564	1 2	1,180	595	314	180
6	2,315	1,060	1,000	395	.372	413	2.0	206.5	208	1.7	1,780	1,821	2.5	1,210	920	426	210
7	1,715	1,360	500	440	.323	417.5	2.0	208 8	212 2	1.6	1,295	1,336	3 0	607	775	396	107
8	2,315	2,160	500	620	.287	440	2.0	220.	220.2	0 1	1,690	1,717	2.1	612	1,095	597	112
9	1,815	2,360	200	620	.263	443.2	2.0	221.6	222.7	0 5	1,395	1,390	0.3	243	995	579	45
10	1,915	2,660	200	700	.264	416.0	2.0	208	208.2	0 1	1,497	1,506	0.6	243	1,015	606	42.5

Sudden Changes in the Form of Liquid Crystals*

By O. Lehmann

Formerly science assumed matter to be continuous, although porous; to be chemically as well as physically homogeneous; the molecular arrangement changing of course in case of anisotropy at the border line between differently oriented parts of a body, in case of crystals, which may, however, be defined as aggregates. For example a spherical crystal has been considered an aggregate; whereas, according to my findings, it may be an individual.

Fig. 1.

Likewise plastically distorted crystals (of gold, silver, etc.) were held to be aggregates of crystal fragments, while the existence of liquid crystals was wholly excluded from the realm of possibility by the "Theory of Identity" (molecular identity in the solid and liquid states), crystallization being made synonymous with solidification, only two sorts of molecular arrangement, the lattice-like order in the crystal and entire irregularity in the molten mass, being considered possible.

My discovery of transparent plastic crystals, whose distortion causes no fragment formation, together with the discovery that by the admixture of foreign substances permanent distortion of crystals can be secured, first justifies the question: "Are such distorted crystals still to be regarded as individual units, or are they aggregates as formerly supposed?" Must we distinguish between true crystalline plasticity, where the crystal remains a unit (for example, soft glass) and apparent plasticity, where a crystalline unit becomes an aggregate of fragments, the only sort of plasticity recognized up to the present?

The further discovery that the form of silver halide stable above 146 degrees, formerly considered amorphous-viscous, was really crystalline, naturally raised the further question, "Can true plasticity go so far that a crystal may be considered fluid, thus contradicting the 'Theory of Identity?'"

I first obtained absolute proof of the existence of liquid crystals with ammonium-oleate hydrate. The proof rests on the demonstration that these crystals possess no "limit of elasticity," as the term is understood relative to solids; for the molecular equilibrium is automatically restored after any distortion; therefore, the crystals must be considered liquid, not solid.

When liquid crystalline ammonium-oleate is drawn into a capillary tube, the molecules arrange themselves radially, with optical axes perpendicular to the walls of the tube. Now, if a short piece of such a tube is placed in water the liquid crystalline mass swells out at either end into cylindrical myelin forms (liquid crystals), consisting of a modification of ammonium-oleate of identical structure with that in the tube.

Thus the existence of myelin forms is a complete contradiction to the above-mentioned assumption that a chemically homogeneous body must be physically homogeneous, for these myelin forms are not aggregates of crystal units, no boundaries being anywhere observable. Nevertheless, points near the surface are by no means equivalent to those near the axis; therefore *the matter is not continuous. The existence of liquid crystals, especially of the myelin sort, is then a certain proof of the molecular theory.*

The existence of liquid crystals also contradicts the accepted theory that only two forms of molecular arrangement can exist, the one entirely irregular, the other, the lattice-like order in crystals.

If, as I first supposed, the molecules are tiny rods, they must be radially arranged when sucked into a capillary tube; hence any current in the mass would alter the lines of interference, since internal friction would retard motion near the tube wall and give the molecules there situated an oblique direction. This does not occur, therefore I now assume molecules to be tiny flat plates, whose surfaces are perpendicular to the optical axis. Other phenomena support this assumption.

Accordingly a cylindrical myelin crystal is in a sense an aggregate of co-axial cylinders of regularly placed plate-like molecules, these cylinders being closed on the ends by hemispheres of like radius.

This peculiar structure demands anisotropy of thermic motion and of expansile force. The molecules easily glide over one another in a direction parallel to their flat surfaces, therefore expansion in the direction of the cylinder axis is greater than in the direction perpendicular to the axis; the *cylinder must then reach such a thickness that the greater capillary pressure of the hemispherical ends must exactly balance the excess of expansile force.*

It has not yet been possible to demonstrate thermic movements and their anisotropy by the observation of the Brownian movement, and since constant transitions from liquid to solid crystals occur it is very possible that the force hindering the surface tension from compressing the liquid crystal into a sphere (myelin forms) is not alone the force of expansion, but primarily the molecular directive force. A proof of this I believe I have discovered in the peculiar behavior of the myelin forms of ammonium-oleate and of protagon when cooled below — 4 degrees.

AMMONIUM-OLEATE HYDRATE.

At ordinary temperatures the myelin liquid crystals of ammonium-oleate are jelly-like threads, easily bent, showing no elasticity, and no tendency to break even when bent double.

If liquid crystalline ammonia is placed under a large watch crystal shaped cover glass and ordinary ammonia allow to flow around and over the preparation, and the preparation set over night in a cool place, then such myelin forms as shown in Fig. 1 will be obtained. Now place these in a temperature of about — 6 degrees and they will take on the zig-zag shapes of Fig. 2. We conclude that in the softer forms (Fig. 1) the molecules adjacent to one another in the direction of the long axis of a cylindrical surface form very blunt angles with one another; and that the straightening of the cylinders in the stable modification at the lower temperature is to be explained by the combination of the plate-like molecules into complicated molecules, which in turn are flat plates. The work done is a process of *direct transformation of chemical into mechanical energy.*

PROTAGON, PHRENOSIN, AND KERASIN.

Protagon behaves practically like ammonium-oleate hydrate. Phrenosin can be obtained in thin plate-like crystals. The liquid crystals obtained on heating these with water take the shape of cylindrical myelin crystals, resembling ray-like projections, and these on cooling suddenly, shrink suddenly to half their length.

If methelyn blue is added to the water in which phrenosin crystals are allowed to swell, so that the water is only tinged, the crystal becomes intensely blue

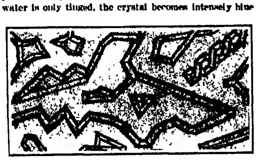


Fig. 2.

(probably through chemical combination). When on cooling the sudden shrinking above mentioned takes place the blue changes to red violet.

Kerasin acts much like phrenosin, expanding and contracting in the same way.

The myelin forms of protagon often lie one within another like the layers of an onion; forms open on one side drawing in, and ejecting smaller forms on solidifying and melting. They remind one of protoplasmic structures. Form and structure are, however, maintained purely by cohesion and molecular directive force, and not by an inclosing membrane.

* Translated from Annalen der Physik for the Scientific American Supplement.

A Dog-Proof Fence

The Department of Agriculture in a recent issue of its "Weekly News Letter" tells farmers how to build a dog-proof fence that will safely protect sheep from the ravages of these animals. The posts should be 7½ feet long, set 2½ feet into the ground, and spaced 16 feet apart. Along the surface of the ground stretch a barbed wire, this to discourage any attempts to crawl or burrow under. At three inches from the ground stretch 36-inch woven wire fencing having a 4-inch triangular mesh. Above this woven fencing, and at intervals, respectively, of 5, 6, and 7 inches three strands of barbed wire are stretched, making the total height of the fence 57 inches. This fence is very durable and inexpensive to build, and it is stated that it will keep out any dog.

Forest Fire Prevention

The prevention of serious damage from forest fires depends largely on prompt information and quick work in checking and preventing the spreading of such fires. In some districts the officials of the Forest Service of the Department of Agriculture have enlisted the interest of residents of their region with excellent results. A recent report of this department states that, in addition to his own fire detection system, the supervisor of the Palisade national forest, Idaho, was notified of each fire by from five to ten different local settlers, who thus showed their co-operation in working for fire suppression.

Recent Advances in Photography*

Some Effects Produced on Sensitive Plates by Material Emanations

By Henry Leffmann, M D, Ph D, Member of the Institute

Although for some years past the labors of many expert photographers have been largely directed to the so-called artistic side of photography, the purely technical and scientific sides have not been wholly neglected, and an inspection of the current journals and recent books will show many interesting results. The basic procedures of development, fixing and toning have suffered but little change during many years. The competitive spirit has led to the introduction of many new developers, but most of these are minor modifications of

Negative produced by aluminum

the original forms, especially as regards the benzine derivatives, and in some cases the change is in name only. A conspicuous instance of the latter is in the use by the Lumière Company of the terms quinomet and metoquinone. In their formula for color plate work the information at hand indicating that the names refer to the same substances and that this is merely an intimate mixture of metol and hydroquinone.

Probably the most important, at least the most generally exploited advance in procedure in this field is color photography. It is curious to note that in the first edition of his work on methods of photography, M. Carey Lea stated that in his opinion color photography was impossible and he gave his reasons for this view. Not long after he modified his view in consequence of the results of research so far as to admit the possibility of such photography. He would surely be interested in some of the plates made to-day by the several processes that are extensively employed, and yet he could truly say that the results obtained by the Lumière, Dufay and Paget plates are not really color photographs, but colored photographs in which the hand of the artist has been substituted by ingenious automatic processes.

One of the latest applicants for favor in this line is the Paget plate. This utilizes a color screen involving the same principle as the older methods, that is an even distribution of the three colors, but in the Paget plate this screen is detachable and hence may be used for many plates. Moreover the reversion of the image as followed by the older methods is substituted by using the plate as a negative and attaching a viewing screen to a positive made in the usual manner. Paget screens are much more transparent than Lumière screens and hence more satisfactory for lantern demonstration; on the other hand they are much coarser and a considerable magnification, as when a slide is projected on large extent, shows the individual colors and destroys the illusion. The total cost of a complete Paget lantern slide is slightly higher than that of a Lumière, but if the operator has a considerable proportion of failures Paget methods are more economical. In sizes of the

Negative produced by Eastman flashsheet

individual color units the Paget screens agree closely with those of the Dufay and Thames plates (the latter is now out of the market).

It is well known to working photographers that the Lumière process employs the principle of reversion of image as the transparency obtained by fixing after first development shows all colors complementary. Working with the color plates suggested to me to try some of the reversal processes with ordinary plates, that is to obtain positives by one exposure. In the early days of negative making, the so-called wet plates, the possibility of direct positives was investigated and several methods were devised. These can be applied to the ordinary dry plates with much success, and although such procedures are of no great practical value or wide application they afford an interesting field for experiment by amateurs.

My experience has been principally with the following method:

Good exposure and good development are given. The developer is washed off and the plate stood, coated side outward, in a developing dish of black material (or the plate is backed by black paper) and several inches of magnesium ribbon are burned a few inches from it. The silver deposit acts as a negative and the unchanged silver compounds are light struck. The plate is then immersed in a solution of potassium dichromate and sulphuric acid, such as is used in reversing Lumière color plates, until the image has practically disappeared. The plate is washed for a minute or so, immersed for a few minutes in a 5 per cent solution of sodium sulphite and then returned to the developer. The second development gives, of course, a positive, which is then fixed and washed as usual. Theoretically no fixing is needed, but in practice it is best to put the plate through the regular hypo solution. The second development will usually be rather slow. It must also be borne in mind that plates well wetted by developer are much less sensitive to light than plates in the dry condition, hence

Relative opacity of common writing materials to rays from luminous paint

if the first development has given a dense picture, a good length of magnesium ribbon should be burned within a few inches of the plate. Care must be taken not to look at the flame and to hold the ribbon with a pair of tongs. All operations are conducted in the dark room. The process will be found useful for making slides in an emergency.

Among the striking discoveries in relation to light, or, it will be more precise to say, radiant energy, is the existence of rays and material emanations which are invisible to the unassisted human eye, but affect ordinary photographic films and many other substances, and in some cases pass freely through objects opaque to ordinary light.

Upon such phenomena as the X-rays, emanations from radio-active substances, ultra-violet and infra-red light I need not dwell here, as ample discussion of these is to be found in recent literature. I want, however, to call attention to a less exploited field, although even in this the basic procedures are not very recent. I refer to what has been called "picture-making in the dark," inasmuch as the etymology of the word photography prevents us from applying it to any processes but those in which light takes part. I need not stop to give any elaborate history of the investigations. An early contribution was that by W. J. Russell before the Royal Society (*Science*, 1900, 11, 487), who tried many substances and obtained curious results from some of them. M. I. Wilbert (*Journal Franklin Institute*, 1900, cl, 388) repeated some of Russell's experiments with success. In reviewing these papers, however, it seemed to me that in many cases the impression on the photographic plate might be due to pressure or mere physical contact rather than an emanation tangible or intangible. I wish to say frankly that I have failed to obtain many of the results reported by Russell and Wilbert even though following their methods as closely as the descriptions available enable. In the later series of experiments I adopted the plan of interposing thin paper, usually the ordinary lantern mat, between the object and the sensitive plate, thus preventing actual contact. This method materially retards the action.

It has seemed to me that the procedures that I intend to summarize briefly may be called skotography (from Greek *skotos*, darkness). One of the most active skotographic surfaces is obtained by scratching or polishing common zinc battery plates. Thin zinc sheets do not seem to be so active, nor does sand papering the zinc plates yield very good results. If one scratches on

Tungsten filament. Ordinary plate. Positive (reversal)

a tarnished and corroded zinc plate a design by means of a sharp steel tool and then lays a dry plate (I used ordinary lantern plates) upon this, with a thin paper between with some perforation or a cut out design, and allows this combination to remain in the dark for a couple of days, a distinct impression will be made on the sensitive plate that can be brought out by ordinary development. Often the metal is active enough to produce a marked effect in a few hours. Russell expressed the opinion that emanations of minute amounts of hydrogen dioxide produce the effects and that the dioxide is in some way formed by the fresh surface of metal, but I have not yet obtained any information to enable me to form an opinion as to the cause. Magnesium and zinc seem to be specially active; thin sheet iron did not produce any effect. Aluminium has moderate activity. I obtained a strong effect with the so-called "flash sheets" manufactured by the Eastman Kodak Company. Bibulous paper impregnated with old oil of turpentine gave no appreciable effect, but impregnated with commercial solution of hydrogen dioxide and allowed to get nearly dry before testing gave a feeble picture.

Some experiments have been made on the photographic and other properties of commercial luminous paint. This seems to be composed largely of calcium sulphide in a fixed oil. I have used it on glass plates and have found the most convenient way to get an even coating is to dilute the material with gasoline and pour

Tungsten filament. "Hydra" plate. Positive (no reversal)

the mixture as was the custom with the collodion used in the old wet plate process. When dry the paint forms a somewhat granular slightly cream-colored film, which will emit for some time a soft, bluish light after a few seconds' exposure to any ordinary source of light; but the most satisfactory results are obtained from sunlight and arc light. Incandescent electric lights, even powerful tungsten lamps, are somewhat slow in action.

Many interesting experiments may be performed with

* Abstract of remarks made at the meeting of the Section of Photography and Microscopy of the Franklin Institute and published in the *Journal* of the Society.

the coated plates. If a piece of ordinary blue and ordinary red glass are placed upon a luminous-paint surface and then exposed to the direct light of an arc lamp for about half a minute it will be found that under the blue glass a strong luminosity is developed, but under the red glass almost no effect is produced. A still more curious effect is that if the entire surface of a coated plate is made luminous and then a portion covered with red glass and again exposed to the light that part under the red will rapidly lose luminosity. The effect may be also shown by covering a portion of the luminous surface with opaque paper and holding the plate near the red light of the dark room. A rapid falling off in luminosity will occur over the surface illuminated by the red rays. I do not mean that the luminosity merely appears less in the red light, but it is actually diminished.

Luminous paint may find a practical value in some copying work. Ordinary paper is moderately transparent to it but writing and printing inks are rather opaque. If therefore we render a plate luminous, place it beneath a written or printed page and lay a sensitive plate upon the page (these operations being of course carried out in the dark) it will be found that an exposure of ten or fifteen minutes will suffice to make a latent image on the sensitive plate which can be developed in the usual way. Experiments with gelatine colored with artificial colors have shown that the rays from luminous paint pass freely through violet and blue films but scarcely at all through green and red films and therefore no great difference is noted in the negative obtained when such screens are used with ordinary and with panchromatic plates. The panchromatic plates furnished by the Paget Company, which cannot be developed in red light, and the common lantern slide plates which may be used freely in red light gave nearly the same negatives. A Lumière color plate was also tried. It was found that no appreciable effect was obtained through the green and red films.

So far as I have experimented the emanation from luminous paints goes equally through glass, quartz, thin films of celluloid, gelatin, barite, calcite and kyanite, but this phase of the problem is still under investigation. A photographic novelty of practical value is the Paget Hydra plate. The emulsion of this contains some hydrazin sulphate, a synthetic product which materially controls over-exposure. I have made tests of the plates by exposing them to the light of a 60 watt tungsten within a few inches of the camera for ten minutes. This is sufficient to produce complete reversal by over-exposure in an ordinary plate but reversal did not occur with Hydra plate. Several important uses of such a plate will occur to practical photographers.

Health Requirements for the Aeronaut*

[The letter here published in the form of a much condensed translation was delivered before the Wissenschaftliche Gesellschaft fur Flugtechnik of Berlin and is published in the latest yearbook of that society. The same year-book contains a valuable paper on "The Eyes of the Aeronaut" by Dr. Hilbert, while the preceding volume contains a useful résumé of the physiology and pathology of aeronautics by Dr. Friedländer. We regret that we have not space to publish complete translations of these three memoirs, as there is comparatively little literature in English on the medical and physiological aspects of aeronautics, important as these subjects are.—EDITOR.]

IN a vehicle of any kind, whether of land, water or air, the safety of the occupants is more or less dependent upon the physical efficiency of the driver. The degree of such dependence varies, however, with the kind of vehicle. Thus on a locomotive the place of a disabled engineer can generally be taken for the time being by the fireman, while in a dirigible airship the pilot can be replaced by some other member of the crew, though such substitution is an unsatisfactory makeshift, especially because the man who is disabled is himself likely to require the care and attention of at least one other person. On the other hand, in the case of the automobile and of the aeroplane there is generally no question of substitution in an emergency, a very slight degree of physical incapacity on the part of the driver or pilot is likely to be attended with fatal consequences to himself and his companions. In an ordinary balloon the pilot has generally one or more companions, but these are not often fully competent to take his place.

So far as these considerations apply to aeronautics, the only possible safeguard against accidents due to the disablement of the pilot is a thorough medical examination of the latter before he obtains his license and the imposition of rigid requirements as to health and physique. Until a few years ago German air pilots were not required to pass any medical examination. Even now the examinations prescribed by the different societies are by no means uniform, nor is there any well-defined consensus of opinion on the subject. Hence the following attempt to outline the essentials under this head.

The examination should take account first of all conditions that might lead to functional disturbances under ordinary terrestrial conditions, and second to those that while not likely to give rise to serious derangements under such conditions might nevertheless do so under the more exacting conditions that obtain in aeronautics. Some useful hints as to points to which special attention should be directed may often be furnished by the family history. Thus the following questions are absolutely necessary: Has there been in the applicant's family any case of insanity? Epilepsy, or other nervous disease? Alcoholism, Suicidal mania? Tuberculosis? If the answer is affirmative an especially rigid examination must be made of the applicant's nervous system or lungs, as the case may be, and of his personal history with respect to these organs.

In making inquiries as to the medical history of the applicant himself, it is advisable to ask leading questions and to aid the applicant's memory as much as possible, as it is easy under such circumstances to forget or pass over, as unimportant, details of great significance. The following questions will be in order:

1. What illnesses have you had?
2. Have you ever had articular rheumatism, hemoptysis (spitting of blood), hematemesis (vomiting of blood), angina pectoris?
3. Have you ever had any mental or nervous disease, especially one involving lapse of consciousness or attention, etc.
4. Have you ever been injured, especially about the head; broken a bone, suffered a sprain or dislocation? Have you ever undergone an operation?
5. Have you any disease of the eye or the ear?

The answers to these questions should be signed by the applicant.

The portion of the examination blank reserved for the personal observations of the physician usually contains the questions: Is the applicant known to the physician? Has he ever been treated by the physician and for what? To these I would add: Has the physician ever made an air voyage with him? Other questions to be answered by the examiner are:

Does the applicant give the impression of a strong and healthy man?

Physical strength is essential, as the task of the aeronaut, whether in an aeroplane, dirigible or ordinary balloon, is laborious under normal circumstances and may become extremely so, as for example when the occasion arises to handle sacks of ballast rapidly.

Are his limbs in any way weak or defective? Are there any malformations of the bones, and if so do they interfere with the use of the limbs?

Evidently a pilot needs sound limbs, as he may have to climb a rope ladder, ascend the suspension gear of a balloon, climb down from a tree in which his craft has landed, etc. In case a limb has been injured the cure should have so far progressed that no special precautions or nursing of the limb are necessary, otherwise attention devoted to this object may cause inattention to aeronautical duties.

Is the voice strong? Does the applicant stutter to any marked extent?

In any form of aircraft except the aeroplane the pilot will often have occasion to give rapid orders, which must be distinctly heard and understood.

What is the conformation of the thorax? Are the lungs sound?

The form of the chest often gives a hint as to the state of the lungs. Tuberculosis should debar the applicant, as even in its early stages there is danger of hemorrhage, and also emphysema, which may become dangerous at high altitudes on account of the difficulty of perfect exhalation.

Is the heart sound? Is there any lesion of the blood-vessels?

Among cardiac troubles we must especially look out for weakening of the heart muscles and valvular defects. This follows first of all from the mere physical labor that may at times be imposed upon the aeronaut. What is true of the heart is also true of the blood-vessels. Even a moderate degree of arteriosclerosis unfits the applicant for such exertions; moreover, aside from the danger of rupturing the vessels, this disease, by diminishing the caliber of the arteries, causes an insufficient supply of blood to the brain; the reduction in the oxygen content of the air at high levels promptly aggravates this condition and disturbs the mental functions, causing dizziness, uncertainty of movement, forgetfulness, etc.

As to the effects of altitude on the circulation and breathing, it is not necessary to insist upon the attainment of excessive heights, at which the pilot would be expected to resort to the inhalation of oxygen. Provided the apparatus works properly this process is not attended by danger, and high flights under such conditions make no special demand upon the physique. On the other hand, it is necessary to insist upon the ability to ascend to heights of from 10 000 to 13 000 feet without the use of oxygen and without any diminution of efficiency. The balloonist must expect at times to be carried up to such heights, either on a sunny morning after a nocturnal ascent or in ascending air-currents. I myself recall having been carried up almost instantaneously, during a thunderstorm, from a height of 3 300 feet to over 15,000 feet, while my companion sat in the violently swinging car, helpless with seasickness and altitude sickness. I have heard of cases of altitude sickness at 6 500 feet with nausea, shortness of breath and livid color, while in one case breathlessness and *malaise* began at half this altitude. Evidently a pilot suffering with altitude sickness cannot be depended upon to perform his duties efficiently. In order to test the applicant in this respect, a trial ascent to at least 12 100 feet should be required.

We next come to the abdominal organs. Under this head I think it may be stated that any condition that causes pain or discomfort should be regarded as prohibitive on account of its effect in distracting the aeronaut's attention from his duties. Hernia is prohibitive only in case it interferes with freedom of movement.

Chronic disease of the middle and inner ear must be considered prohibitive, at least in the case of aviators, especially on account of its impairing the equilibrating function of the ear (i. e., of the statolith). Stubborn catarrh of the Eustachian tube may give rise to much discomfort on account of rapid changes in atmospheric pressure, but I should hardly go so far as to reject an applicant on this ground. Marked deafness I consider prohibitive.

We now come to the most important class of defects, viz., those of the nervous system. Under this head we may consider separately those derangements that merely affect the motor and sensory apparatus and those that involve mental disorder. Derangements of the first class are easy to detect according to well known methods. We can test for paralysis or muscular atrophy, examine the reflexes, look out for muscular twitching, etc. All nervous affections that impair the strength or accuracy of bodily movements should be considered prohibitive. We can never be sure how rapidly such conditions may become intensified. Thus, for example, a very slight degree of tabes (incipient locomotor ataxia) is a sufficient ground for rejection.

Among mental affections those characterized by melancholia need hardly be considered, as the patients in such cases are not often desirous of becoming aeronauts. Far more dangerous is the opposite condition of exaltation, or hypomania, which is often difficult to recognize from external indications and which may lead to impulsive and reckless acts.

Incipient paralysis is especially dangerous. Every possible precaution must be taken to exclude such cases whenever suspicion exists; not only should the medical history of the applicant be thoroughly investigated, but decision should be reserved and a reexamination made after a lapse of time. As paralysis is so commonly a result of syphilis, and as it may be extremely dangerous even in its early stages, when diagnosis is difficult, I am inclined to apply the same rule to the aeronaut that Dr. Placzek has laid down for railway employees, and exclude all syphilitic applicants, though I admit that this is rather sweeping.

Mild cases of epilepsy are not susceptible of diagnosis in the intervals between seizures; they can therefore only be detected by a careful investigation of the medical history.

Alcoholism, the more severe forms of which can be readily diagnosed, is absolutely prohibitive.

We have lastly to consider a variety of nervous disorders which are, as a rule, easily detected and recognized in ordinary medical practice, when the patient voluntarily confides his symptoms to the practitioner, but which are by no means so easy of diagnosis when the patient is undergoing examination for a pilot's license and is anxious to avoid rejection. These include neurasthenic and hysteric conditions, as well as ordinary "nervousness." They can be detected only by means of actual ascents under an experienced pilot, who should report all abnormal actions on the part of his pupils to the medical examiner; the latter will decide what importance should be attached to them. Most aeronauts are more or less nervous and upset before an ascent. Seasickness, when due to the imagination rather than to the actual movements of the balloon-basket, excessive timidity, strong aversion to looking downward, the desire to jump overboard, and hallucinations of various sorts are all to be considered in deciding upon the fitness of the applicant. Whether any of these common manifestations should be considered prohibitive in certain cases must be left to the judgment of the physician, who should preferably be himself an aeronaut.

* Abstract of a letter by Dr. E. Koschel.

"Suction" Between Passing Ships—II*

Important But Little Understood Forces Affecting the Motion of Vessels

By Sidney A Reeve, M E

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No 2036, Page 32, January 9, 1915

THE form in which the stream-line ship derived mathematically from sources and sinks was left by Mr Taylor's last addition to its theory was still unsatisfactory for the analysis of suction between actual ships Its outline was everywhere convex Stem and stern were both rounded there was no hollow entrance or run and the middle body was not parallel While such a ship form might do for the study of the general principles (which indeed could be well understood without any stream-line analysis) yet for any estimate of *quantitative* aspects of the problem a better ship-form *must* be had The magnitude and exact form of the constrained wave accompanying a typical steamship could be had only by mathematical deductions which were based upon a typical ship model having a long parallel middle body hollow entrance and run and sharp prow and stern

To the writer it appeared likely that Taylor's method might be made to yield these results provided a suitable function of sources and sinks could be found to form the premises This could be determined only by the cut-and-try method which as each try involves tedious repetition of simple computations proved to be laborious However the nineteenth function tried gave a fairly satisfactory model as may be seen from Fig 7 the ship form in which is a mathematical stream line and not an assumed form and upon that model all the curves and contours presented here are based [1]

Taylor's method was modified slightly in order to facilitate the work of investigating many different premises by taking a large number of points and relying upon averages rather than integrating a separate curve for each one of the thousands of points investigated yet even with this the method is laborious The ship's length was divided into twenty parts and in terms of these longitudinal units and for each one-fifth the beam extending laterally the stream lines were computed over a sea-surface extending nearly a ship's length forward of the stem and nearly two ships lengths abeam In this work only one quadrant from the course ahead to either beam need be computed because the mathematical treatment makes the four quadrants symmetrical But in actuality the viscosity of the water and the energy lost in wave-making make the constrained wave astern smaller than that ahead

This plan would apparently give over two thousand observations in each quadrant but in the regions farthest from the ship many points were omitted the contours there being of less curvature Taylor's intermediate curve was plotted on a sheet 4 feet square the largest practicable in this case and final values of stream line widths were computed to four decimal places (preceded by a characteristic) with intermediate computations carried to five or six places Students repeating this work will do well to plan for greater accuracy than this for whatever scale is adopted at the start must be adhered to throughout the work The stream-lines were all drawn as accurately as possible, but the computed values were charted thereon and formed the sole basis for deduction no values being taken off graphically except in the use of the intermediate curve where precautions were taken to have the graphical work sufficiently accurate

Fig 7 gives the results for a single ship The model has a beam one-eighth its length, with a parallel middle-body of half its length sharp stem and stern, and slightly hollowed entrance and run The draught was taken as four tenths the beam The curves are true for a relation of speed to length indicated by any of the following proportions from which other lengths or speeds can be interpolated but the numerical scale of elevations will vary with the square of the speed, that noted in Fig 7 being true only for an 800-foot ship going at 20 knots

Length ft	200	300	400	500	650	800	1000
Speed knots	10	12 35	14 14	15 82	18 08	20	22 37

The curves of Fig 7 are level contour lines For readers not familiar with the preceding article, it may be repeated that these contours show not actual elevations or depressions of the sea, but surpluses and deficits of sea-pressure in an imaginary sea having just the depth of the ship and confined by a thin sheet of rigid ice on its surface These are assumptions necessary for practicable mathematical treatment but it is obvious that while the vertical release of the water under actual conditions would vary these curves somewhat yet their relative disposition cannot be far from those shown

Through the center of the ship's displacement are drawn the 45 degree lines which would be its mean sea-level contour if its displacement were reduced to a single point Asymptotic to these lines are the approximately hyperbolic mean sea-level contours due to the elongated form of the ship These hyperbolas extend indefinitely away from the ship, but all the other contour-lines are closed curves or would be if the diagram were sufficiently extended

Between the limbs of each hyperbola ahead and astern of the ship rises an oblique cone of water at stem and stern, reaching an altitude of 8 feet above mean sea-level This altitude it is to be remembered, is *exclusive* of the bow waves or stern waves It is relatively to this conical surface that these waves raise their crests and depress their troughs While the peak of this constrained wave is sharp its base is very broad At a distance of half a length ahead of the stem the sea is elevated 3 inches over an area extending more than a length athwart the course But on either beam the depression of the sea is still more marked in extent For five-eighths of a length out away from either rail the sea is a foot or more below normal level while the 3-inch depression extends out to a distance probably of several lengths not measurable on the diagram It is this wider area of depression than of elevation which probably has given the name suction rather than repulsion,' to the phenomenon It is noticeable that the deepest depression does not occur directly abeam but on either bow or quarter where occurs a pocket reaching a depth of 9 feet From this point the water line rises to less than 5 feet below normal sinks again to more than 5 feet where the curvature of the bow alters to the straight lines of the middle body finally rising to less than 4 feet at mid length The peculiar form of the 4-foot curve led to its being checked by a fresh computation for that district upon a larger scale, but the result only confirmed the earlier curve, strengthening the writer's confidence in the virtual accuracy of the entire diagram

The symmetry of these constrained waves as between bow and stern depends not merely upon the assumption of perfect fluidity in the sea-water, but upon levelness of sea-bottom Should the ground beneath the ship be rising this constrained wave will be in process of formation to the magnitude shown, from the smaller constrained wave of deep water, and this formation must take place first at the bow This explains how it is that a high-speed boat such as a destroyer will feel a bank many feet beneath its bottom, so forcibly as to fetch the crew up against rails or bulkheads As the bow passes over the bank this cone of water must form ahead while the stern has yet no corresponding cone pushing it ahead

These contours also explain how it is that a ship's resistance is so markedly increased in shoal water It also explains how a high-speed boat seems to settle in the water One case is reported where a paddle-steamer failed to come to speed on her trial trip, it being found finally that her paddles had not been located with a view to this depression of the water on either beam so that before she attained full speed the floats lost their full contact with the water In all ships of appreciable speed having a painted water-line the uncovering of the underbody throughout the greater portion of her length by the trough of the constrained wave is plainly visible The heaping of the water about her stem is more or less obscured by the bow-waves, but at the stern although the stern-crest is smaller than the bow-crest, the regathering of the water under the counter is usually plainly to be seen The importance of a fine run for taking advantage of this phenomenon is apparent when it is noted that in the model of Fig 7 the amount of energy constantly being stored in the constrained wave is some 40,000 horse-power The bulk of this power is being as constantly regained at the stern, but because of the viscosity of the water, not all of this enormous supply comes back It is the office of the ship's run to regain as much of it as possible.

III INTERACTION BETWEEN TWO OR MORE SHIPS.

The problem of determining the distortion of the sea-surface in the neighborhood of two ships moving on parallel courses, and overlapping, which is the standard position for the development of suction forces, is impossible of exact mathematical solution, so far as the writer is aware even with the aid of the imaginary sheet of ice and the restriction of the water to motion in horizontal directions But the stream-line method offers at least two ways of securing approximations to the truth which are near enough to shed very much more light upon the situation than is available in our present state of knowledge

The first method consists in taking two sets of stream-lines identical with Fig 7, overlapping them in the relationship between the two vessels which is to be investigated and then adding them

The result of such a procedure is shown in Fig 8, which is derived from two ships like Fig 7, placed on parallel courses a half-length apart, with one ship lapping a quarter-length over the other The resultant stream-lines and sea-contours are quite accurate, but they have now lost their practical value as being founded upon ship-models fairly typical of actual ships For the models secured by this mathematical method are themselves fluid (until we imagine them momentarily solidified) and therefore each ship-model has now become warped narrowed, and distorted by the influence of the sources and sinks forming its neighbor The beam has been reduced about one-half, the axis of the model is no longer straight nor co-incident with the intended course, while the general heading of each model has been sheered away from its neighbor

All of these features tend to minimize the mutual hydraulic reaction due to the solidity, in actual practice, of the neighboring hulls which is called 'suction" Nevertheless Fig 8 shows plainly, in comparison with Fig 7 the general directions in which the sea-contours about each ship are modified by the presence of the other First, following out the 45-degree lines from the center of displacement C common to the two ships, it is evident that the area of superpressure included in the hyperbola ahead of the leading ship must be unsymmetrically placed All the curves depicting the cone of superpressure ahead of the leading ship corroborate this view Her head is being steadily pushed to [illegible] more than is visible in the small scale reproduction of the curves

But it is also true, as could not be predicted from the general disposition of the 45-degree lines, that the head of the following ship is also being pushed to port by a cone of superpressure ahead, which bears much more obliquely than in the case of the leading ship It is the pressure of this cone of water into one side of which the following ship is always heading, which crowds her over towards the other's quarter It is the rapid exaggeration of this cone, both in altitude and obliquity, by the piling up of the water displaced by the leading ship, as soon as the following ship yields at all to its insistent pressure, which explains the suddenness with which suction collisions occur, and the complete unmanageability of the following vessel as soon as she is permitted to head in the slightest degree towards the other

It is also to be noted that in Fig 8 the altitude of all four cones of water has been exaggerated, both in comparison with Fig 7 and with each other, for, since the beam of the vessels has been halved, the cones of Fig. 8 should naturally be only 4 feet high, and the same at each end of the ship But in Fig 8 the cones at the overlapping ends are nearly 5 feet, and at the distant ends well over 5 feet, in height, or nearly a quarter larger than proportionate to Fig 7 At the same time the larger cone constantly retards the progress of the leading ship, while accelerating that of the following vessel.

One of the earliest instances of hydraulic interaction between following ships ("Narragansett"-"Providence," in 1869) witnessed how this last-mentioned feature may lead to the actual towing of a slower consort for considerable distances by the leading and slightly faster of two vessels upon parallel courses in restricted waters, purely by "suction." This is what is called in America a "wireless tow." The phenomenon may not result in collision. In the case cited the "towing" continued for several miles. The final collision, occurring in Hell Gate, may or may not have been materially [illegible] suction forces. The action in [illegible] [illegible], and one of the kind, although [illegible], [illegible] which the pilot of a following vessel may [illegible]

* Reproduced from *Engineering*

[1] Students should be cautioned that all writers on this stream-line topic complain of the labor and tedium of computation The writer appreciated this only after he had become involved The processes are simple and anyone in command of a corps of clerks could easily carry the Taylor method to further and better results than are here presented But anyone attempting to investigate alone as a spare-time occupation, must be prepared for very slow and tedious progress.

his ship is being "picked up" or accelerated by the faster ship which has almost passed When this occurs, although collision may not be inevitable, it is a sign that his ship is in unstable steerage, and that the first irregularity of sea-bottom, or projecting pier or even the approach of some otherwise harmless third vessel, may precipitate a disaster against which all his skill and engine power will be unavailing But even a slight sheer away from the other ship, taken in time will suffice to avert it

One method by which Fig 8 might be developed into a set of contours or typical ship-models would consist in starting all over again from initial functions of sources and sinks which would be arbitrarily selected upon curvilinear axes (convex towards each other) and of double strength, so judged that when the two sets of stream-lines were added the effect would be to straighten out the hulls into normal shape on straight parallel axes. But this method promises an exaggeration of even the laboriousness inherent in the work reviewed thus far While its fruits would be mathematically exact, and therefore worthy of full confidence its penalty in the form of labor was too forbidding for the writer's command of leisure and an easier side step was taken around the difficulty

This consisted in going back to the original set of stream lines from which Fig 7 was developed and superposing them as for the preparation of Fig 8 but then regarding the two hulls as remaining solid This method gives very closely the volume of water entrapped by each stem as it cleaves its course which volume must find its way aft as best it may constrained by solid hull and sea bottom and superficial ice The question then remaining is Along what stream lines does this water distribute itself?

This question cannot be answered mathematically but the guidance provided by the composition of Fig 8 permits a fair estimate to be made as to how the exact stream-lines would be influenced by the additional water entrapped on each side of each hull by the solidity thereof The estimate thus applies merely to a minor correction of values already obtained with mathematical accuracy, and, although the form of the contours is influenced considerably by the method of correction adopted, it is thought that the result is fairly accurate It at least shows accurately the direction in which Fig 8 would be modified if the hulls were solid and the amount of correction in this direction might easily be more than that shown in Fig 9 This diagram I would therefore style a mathematical conjecture

The mathematical form of correction must be one easily applied to thousands of points in repetition The one most readily suggesting itself in view of this requisite and of the facts become familiar during the preceding work, was to assume that the surplus or deficit of water entrapped by the stem is distributed over the sea-surface away from the ship's side in what amounts to a logarithmic curve, approaching zero as the distance increases indefinitely That is to say, it was assumed that 1/nth of the surplus or deficit was retained between the first two stream-lines, 1/nth of the remainder between the next two, and so on The factor n was given a different value arbitrarily, in the light of the preceding work, for each different point of the ship's length.

Whatever criticism may be directed at the choice of this particular method of distribution, it is beyond question that the true stream-lines for two solid hulls like Fig 7 must consist of a distortion or correction of the stream-lines on which Fig 7 was built by some factor which has its greatest effect at the ship's side, with a gradual dissipation of that effect with lateral distance which can never become complete Considering that the uncertainty applies to a minor fraction of a minor correction the form of the resultant contours depending chiefly upon the particular localities in which a positive or negative correction is appended to a previous positive or negative departure of stream line from parallelism rather than upon the magnitude of the correction itself it is believed that Fig 9 is worthy of credence as offering the only approximation to the truth regarding following ships which has yet been offered from even a semblance of a mathematical basis

The contrasts between Fig 9 and Figs 7 and 8 are numerous and interesting In the first place whereas Fig 8 is inevitably symmetrical from its mathematical origin in the sense that it makes no difference in which direction the two ships are moving in Fig 9 this is no longer true Owing to the different surplusage of water entrapped by the two stems which surplus must then travel throughout the length of the solid hull before again exerting its influence upon the water on the other side of that hull the contours about one hull are appreciably different from those about the other The oblique cone of water ahead of the following ship is quite different both in magnitude and angle from that following the leading ship The excess of pressure from one quarter over the other which is the principal force acting to sheer the ship off her course is much greater in the following than in the leading ship which explains again how it is that it is usually the following ship which is deflected

In general however Fig 9 which is really derived by a quite different and independent line of reasoning from Fig 8 corroborates that diagram The leading ship is seen to be sailing continuously up-hill against a cone of water at its stem which is 3 feet higher than that at its stern while the following ship is likewise sailing down-hill all the time into a relative hollow of equal depth This is caused by the leading ship's shouldering the burden of displacing the water for both of them the reaction from which displacement rises under the stern of the following ship and aids her progress

In Fig 9 the pairs of cones of water ahead and astern of the ships respectively are each merged into a single hyperbolic cone asymptotic to the 45-degree lines whereas in Fig 8 they were separate but this is because in Fig 9 the ships lap by four-tenths of a length whereas in Fig 8 they lapped by only a quarter length It is probable that a slightly greater lap than four-tenths would exaggerate the mutual distortion of contours and the development of suction forces but the labor of computing even a single relative position was so great as to be prohibitive of any comparative investigation of different ones In Fig 9 as in Fig 8 the lateral distance between the two courses is a half-length but in Fig 9 the beam of the ships reduces the minimum distance between hulls to about 0 385 of a length In both diagrams the full line contours are those drawn through computed points while the broken lines indicate where the contour was interpolated by estimate

While Fig 9 gives the best foundation from which to estimate the effect of variations from its particular arrangement of dimensions of hulls the results of this particular arrangement can best be seen in the form of profiles of the water-lines of the two ships—assuming again that the computed pressures of Fig 9 might be translated into actual elevations of water by the removal of the imaginary superficial sheet of ice without altering the values Such profiles are given in Fig 10 in which the vertical scale is exaggerated five-fold for better visibility They are plotted directly from Fig 9

On each profile is shown a conventional center of lateral pressure C, taken at one-fifth the ship's length from the stem Comparing the two profiles, and remembering that the steering of any ship depends upon the horizontal moment developed between the rudder forces at the stern and this center of lateral resistance C (which is always well forward in the direction of the ship's motion) it again becomes obvious why it is that it is usually the following vessel which is diverted from its course Until Fig 9 was developed this explanation had to depend upon the fact that the following vessel was usually the smaller and weaker Now, however it appears that the forces at work upon the after vessel are so much larger than upon the leading ship even when the ships are of equal size and speed that the following vessel must still be the one more liable to diversion from her course even when somewhat larger

As to speed it is not evident just what difference it would make as to relative forces The suction forces are the mutual product of the two ships acting cooperatively They are the result of the aggregate rate of displacement by the two vessels so that any increase on the part of either ship must result in the exertion of increased divertive forces upon both

Fig 10 should make it plain why it is that a vessel in the grip of suction forces pays no attention to a hard over helm Making every allowance for the exaggerated vertical scale the length of after body far from the center

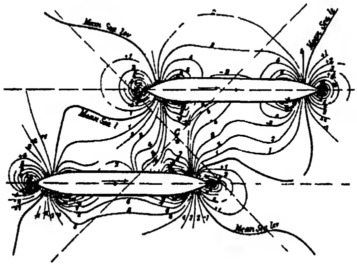
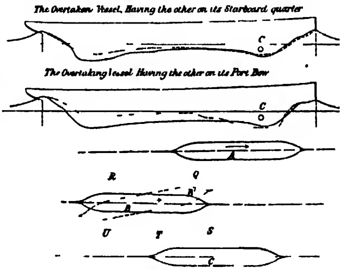


Fig 9



Figs 10 and 11

of lateral resistance which is exposed to a head of several feet of water pressure acting laterally is overwhelmingly larger than any lateral force imaginable to be developed by a rudder It is utterly impracticable to build or navigate ships so as to defy suction forces These forces can only be avoided and that only by foresight

But the most important question of all Why do not suction collisions happen frequently and why do they happen unexpectedly in situations apparently encountered frequently before in safety? remains to be answered The answer involves the third wall of the Venturi passage-way between the two ships namely the sea-bottom or else some equivalent outlying factor not yet brought into the discussion

Figs 9 and 10 are based upon a degree of propinquity which is seldom reproduced in actual navigation even disregarding our mathematical assumptions of imaginary ice etc That is to say ships seldom move at full speed on parallel courses within half or third a length of each other in water barely sufficient to float them The explanation of why suction collisions do not occur is that even a moderate deepening of the water below their draught rapidly moderates the forces at work so that by the time the water is deep enough to permit full speed it is deep enough to make fairly close overlapping courses safe The explanation why suction collisions do occur when they do is usually the fact that a moderate contribution of solidity to the ship's environment by sea-bottom or by a third vessel or an accentuation by even a slight convergence of courses is competent to exaggerate back into control those forces which the previous depth of water had rendered innocuous

For deep water while reducing the intensity of the constrained wave correspondingly increases its volume or extent and it also permits increased speed on the part of the ship It is when the ship passes suddenly from deep to shallow (or otherwise limited) water that trouble arises This great volume of constrained wave moving at a speed above that attainable by the ship in uniformly shallow water piles up into a degree of intensity which it could never assume in uniformly shallow water If it begets disaster it does so by suddenly releasing an enormous accumulation of energy which the ship has been carrying with her in addition to that currently at work

A glance at Fig 9 will show how rapidly all the con-

ditions creating suction will be exaggerated by any angular swing of the following ship toward the leading one. The two pockets, 11 feet deep, on her port bow and starboard quarter are there because a surplus of water is trying to get to its ultimate destination, which is off her port quarter, as rapidly as possible. To give it the necessary horizontal acceleration a drop in head must occur. But how much more will this region off her port quarter lack its supply of water if the bow swings toward the leading ship, cutting off the channel between them, while the stern swings out, lengthening that route for the water?

But what most commonly happens is that while the courses remain parallel the ships run over a hump in the sea bottom, or they pass a pier-head or bank, which, when opposite the trailing ship's starboard quarter, reduces the pathway for water, and therefore deepens the pocket on that portion of the hull - the former being the more common cause of disaster. Such a combination of circumstances will instantly exaggerate into uncontrollability suction forces which previously -perhaps during a considerable period of overlapping -had proven harmless. It may be that the vague fear of suction, so often mentioned by pilots as felt when steering such following courses, had been stilled by such preceding period of security, only for the relaxation of alertness just at the time when the alteration in the depth of water created the real danger. Too many suction collisions occur just where the water shoals slightly to permit disregard of this factor, although it is impossible to bring it into any mathematical discussion. Nor are the data of actual disasters sufficiently accurate so that the shoal can often be located exactly, in relation to the ships, when action occurred. But it is seldom that unquestionable suction occurs when only the two ships are present, surrounded by open water.

A similar contributing factor in many of the minor cases occurring in American inland waters is a third vessel. Fig. 11 shows how such a combination may produce disaster. A and B are ships moving in the same direction on parallel courses and overlapping. C is a third ship upon another parallel course. If C be moving in the same direction as A and B, B is plainly (from Fig. 9) steering in very unstable equilibrium, sailing steadily down-hill into the pocket created by the displacement of A and C. The slightest swerve of B's head towards A, as at B^1, will not only starve the Q region of water needed at R, as would be true if C were not present, but will trap an over-supply of water between B^1 and C, exaggerating the pocket at U and creating an additional one at T. B's head will be crowded towards A and her stern and middle body drawn towards C with irresistible forces, which grow stronger with every additional degree of swing.

Not only are there several instances where this situation has led to disaster after two of the three ships (say A and B) had sailed closely but safely for some time, but there are a few cases where the only plausible explanation of an otherwise inexplicable sheer of B into A was that C had exerted this same effect, even although passing in the opposite direction. These are all in the restricted channels connecting the Great Lakes, used by boats of heavy tonnage; but the speed was correspondingly low, a circumstance minimizing the danger of suction.

Only two attempts have been made, to the writer's knowledge, at the experimental determination of suction forces. One was the Taylor experiments with models in the Washington towing-tank already mentioned. These observations confirmed in every way the hydraulic theory already presented. They were limited in their educational value, however, by the fact that the models were fixed relatively to each other, thus preventing any knowledge as to how rapidly these forces are enhanced by the natural swing of the vessels towards each other. Any determination of this acceleration will, of course, be very difficult; but since it is quite impossible by mathematical analysis, and is virtually impracticable even with models (because the prime question is whether such action occurs more or less rapidly, in full-size ships, than the human organism can act), it is unfortunate that the ideal ships of the British or United States navies cannot be utilized for this purpose. When suction was the thing anticipated and under measurement, it would be easy to make the experiment safe.

The other known set of experiments was made with actual vessels, if small ones, by Prof. A. H. Gibson and Mr. J. H. Thompson (reported in *Engineering*, September 27, 1912). These experiments also corroborated hydraulic theory in every respect. Their chief drawback was the inequality in length between the two boats, as well as their small size. One, a steam yacht, used as the leading vessel, was virtually three times the length of the other, a motor boat. From Fig. 9 it will be obvious that it is important that the two ships be at least similar in length. In one prominent suction collision, however—the "Brockton"-"Hartt"—the leading boat was much larger than the attracted boat; and in this instance, too, arose a beautiful example of interaction between the constrained wave of the smaller boat and the echelon wave of the larger (the two waves being of similar length) as the contributing cause which converted an otherwise safe situation into a disastrous one. This collision is further the more remarkable in that it occurred in comparatively deep water, outside Sandy Hook, between vessels of comparatively light draught.

There will be given a brief description of a few of the more prominent or illustrative suction collisions. Anyone who has studied the entire list of such recorded disasters will be impressed with the clear way in which all but a very few are explicable as natural, if not inevitable, phenomena, so soon as the foregoing hydraulic theory is applied. But he will also be impressed with the variety of combinations of circumstances which may arise to create suction forces powerful enough to produce disaster, and thus to record themselves in civil suits at law. These combinations are too many to be always remembered, nor can the list of possible ones be already exhausted. We have not yet finished with suction disasters. While channels are continually being deepened, longer, deeper, and more powerful hulls are appearing at an even higher rate of progress.

For these reasons the subject cannot be dismissed without at least a word as to the possibility of preventing future suction collisions. The general education of pilots is one obvious measure of relief, and it is to that end that the present article is primarily aimed. But another more formal and reliable preventive is feasible, in the writer's belief, and this is an amendment to our international navigation laws covering the case of overtaking vessels. The suggested amendment (which is offered tentatively, by one who is not a certificated navigator) should read to this effect:

That when an overtaking vessel asks for and receives from the leading vessel permission to pass, by the exchange of the usual signals, the acquiescence of the leading vessel shall enforce upon both vessels the slowing of their engines, those of the following vessel being reduced to "half speed," and those of the leading vessel to "slow," which condition is to be maintained until the overtaking vessel's stern has passed clear of the overtaken vessel's bow. In restricted waters such a procedure is the only safe alternative to the overtaking vessel remaining astern until wider sea-room has been reached.

(To be concluded.)

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The Inductance of a Coil

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

IN the SCIENTIFIC AMERICAN SUPPLEMENT of October 10, 1914, appeared an article by Kenneth Richardson, in which was given a formula for the calculation of the self-inductance of a coil.

I wish to call attention to the fact that the formula as given is, in general, inapplicable, and of no practical use for the purpose stated in the article. It is "exact" only in case $\frac{D}{l}$ = a certain value, where "D" is the diameter, and "l" is the length of the coil. The quantity "101.5" has a different value for every change of $\frac{D}{l}$. Using K for "101.5" the formula may be written:

$L = \frac{N^2T^2}{l}K$ where:

L = Inductance in centimeters.
N = Total turns.
T = Radius, centimeters.
l = Length.
K = A constant, depending in value upon $\frac{D}{l}$

The calculation of the constant K is a long and difficult matter and beyond the ability of the average amateur radio experimenter. Likewise, the calculation of the self-inductance of short solenoids is by no means simple when accurate results are required.

To illustrate by an example the error if one uses the formula given by Mr. Richardson: I shall take a coil which would be suitable for use as the primary of an oscillation transformer for amateurs. Dimensions of coil:

D = 20 centimeters, or 8 inches (approximately)
T = 10 " " 4 " "
l = 10 " " 4 " "
N = 8

where:

D = Diameter
T = Radius
N = Total turns
l = Length

Calculating the inductance of the above coil by Nagaoka's formula we get: 13,277.6954+ centimeters, or 13.2776954 micro-henries. This value is extremely accurate, as checking with the absolute formula of Lorenz, the difference is only 0.057+ of one centimeter.

Calculating the self-inductance of the same coil by the formula: $L = \frac{101.5\,N^2T^2}{l \times 1000}$ we get 25.984 micro-henries, as the approximate self-inductance.

From the foregoing it is evident that the error for a coil in which $\frac{D}{l} = 2$ is approximately 95 per cent.

In order to have gotten highly accurate results we should have had to use 51.805+ instead of "101.5," in the case of the coil which we considered where $\frac{D}{l} = 2$.

In the above case the self-inductance is the current sheet value and requires a correction, depending upon the size of wire used, for the true low frequency inductance. If we use No. 4 B. and S. wire, the self-inductance will be 1.0546662 micro-henries greater, approximately. The low frequency inductance then is: 14.342+ micro-henries. Knowing the self-inductance exactly, the method of obtaining the dielectric constant as described by Mr. Richardson is simple and should be suitable for amateurs. But the self-inductance cannot be calculated with the required accuracy by the formula given, excepting, as before stated, in the case of a coil of certain dimensions.

J. E. FREDERICKS,
El. I. C. Radio, U. S. N.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JANAUARY 16, 1915

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) " 3.00
American Homes and Gardens . . . " 3.00
The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX] NUMBER 2038] NEW YORK, JANUARY 23, 1915 [10 CENTS A COPY $5.00 A YEAR

Scene in the Bitter Root Mountains where the Chicago Milwaukee & St Paul Railway is to supplant steam with electricity

RAILROAD ELECTRIFICATION IN THE FAR WEST —[See page 56]

Malaria and the Transmission of Diseases

Radical Improvements Needed in Public Health Methods

It is curious that though the transmission of disease is a matter of such vast import to every one of us, it has received so little investigation in the past. Even up to the middle of last century our inquiries had led us little further than what I call the subscience of the subject—that is, we distinguished, classified, and named our various bodily infictions. Bacteria are easily saprophytic and may have many paths of transmission, and I fear that we are still very much in doubt as to the most important of these numerous routes.

Some of the largest parasites were known in antiquity, but the ancients possessed quite a wrong notion of their origin, which they attributed to spontaneous generation. In the seventeenth century, however, Redi proved that this hypothesis does not hold for certain insects; and later Pallas argued that parasites originate *ab ovo*, like other animals—that is, that their eggs escape from one host and enter another host, thus tending directly to the presence of the parasites in the latter. This history possibly still holds for certain parasites; but in 1790 Abildgaard showed by experiments that some parasites of fish live not only in those fish, but a part of their existence in certain water fowl; and this extraordinary law, which may be called after De Barry's term, slightly changed, the law of metaxeny, was proved during the middle of last century to apply to a large number of Trematodes and Cestodes. Subsequently Leuckart, Melnikoff, and others extended the law to cover other species, including species of Nematodes. A most important case was that of the *Filaria medinensis*, the famous guinea worm of man, which was shown by Fedschenko in 1869, following a suggestion of Leuckart, to be in common with man and a water flea (*Cyclops*). All this constituted a discovery which was both remarkable in that it exhibited the wonderful devices of nature for propagating parasites from host to host, and was also of the highest importance to mankind (though few recognized this point at the time) because it showed us how many of our great diseases are likely to be acquired.

Let me dwell on this point for a moment. Parasites, accustomed as they are to dwell in the safe retreats of certain portions of their host's body, must be exposed to great dangers whenever they come to pass, as they must do, from one individual host to another. Thus, if this passage is effected merely by the egg, it is obvious that the eggs must be poured out in immense numbers to compensate for their immense destruction outside the body of the host, while it would always be probable that only a very minute proportion of the eggs would ever find their way again into fresh hosts of the proper species. In order to avoid these difficulties, nature, I presume through an infinite period of evolution, has enabled many parasites to acquire a more safe and certain route of entry—through other animals which are associated frequently with their first species of host. Remember that nature is as solicitous for parasites as for the higher animals which contain them. She thinks no more of man than of the minute germ which infests him.

Following upon the discovery of Fedschenko, Manson in 1877 showed that the embryos of another *Filaria* of man (*Filaria bancrofti*) develop in a species of mosquito, probably a *Culex*. The life-cycle of this parasite, up to the point to which he carried it, was closely similar to that demonstrated by Fedschenko for *Filaria medinensis*; and Manson did not complete the story. Lastly, in 1880, Laveran made the most important discovery that malaria is associated with a minute protozoal parasite of the blood; and his observations were followed by those of Danilewski and others who showed that similar parasites are to be found in many animals.

But up to the last decade of last century we still could form scarcely any definite idea as to how the protozoal parasites pass from one individual host to another. The law of metaxeny which had been proved to apply to many of the larger parasites had not been extended to the smaller ones. In 1889, however, Smith and Kilborne discovered a small parasite called *Piroplasma*, in the blood of cattle suffering from Texas fever; and more than that showed that in some mysterious way the infection is carried from ox to ox by means of certain cattle-ticks—though they did not demonstrate in any way that these parasites undergo a metaxenous stage of development in the ticks, and indeed failed to find them at all in these arthropoda. In 1896 also Bruce made his famous discovery that the Trypanosomes of nagana are conveyed by certain tsetse flies, but supposed that the carriage is a mechanical one. And there the matter rested until the solution of the great malaria problem opened up to those interested a new field.

We now turn to the subject of malaria. Economically, as well as medically, it is certainly the most important disease in the tropics, perhaps in the world. It is found almost everywhere in hot climates, and even in most temperate climates during the summer. From statistics we find that as a broad general rule in malarious countries about one third of the total population suffer from attacks every year. But these figures are merely based upon records and do not cover the enormous additional number of patients who remain untreated.

It is remarkable that even more than 500 years before Christ the ancients certainly were acquainted with one great law—namely, that malaria is connected with stagnant water, such as marshes; and there are good grounds for believing that Empedocles of Sicily actually delivered Selinus from malaria by draining its marshes or by turning two rivers into them. This knowledge seems to have been generally held since ancient times, though it must have been acquired quite empirically; but Varro and Columella, at about the time of the Christian era, actually suggested that the disease is in some way connected with insects which breed in marshes. In more modern times, however, malaria has been ascribed to noxious vapors given off by stagnant collections of water—the hypothesis evidently being that the poison is some kind of chemical one. Even ten years after Laveran's discovery we were still completely ignorant as to how the malaria parasites enter the body.

At the same time, however, the hypothesis originally but vaguely mooted by Varro and Columella had been gaining ground. Indeed, Lancisi had repeated the same speculation in 1717 and seems actually to have suspected mosquitoes and to have studied them. In 1883 Dr. A. F. A. King wrote a most able paper on the subject, in which he gives no less than 19 reasons why mosquitoes are likely to carry malaria. He thought that the insects bring the poison from the marsh and inoculate it into men. Next year Laveran himself and Robert Koch independently enunciated the same speculation, but gave few reasons and no experiments in support of it. Ten years later, however, Manson repeated the hypothesis, but in a different form. By this time (1894) the parasites of malaria had been very carefully studied, and were shown to possess, not only certain forms which are provided for their propagation in the human host, but also other forms which, when the blood is freshly drawn, emit several so-called flagella. These latter forms had really led Laveran to his discovery, but their zoological significance still remained quite unexplained. Manson now urged that the flagella given off from these forms are really flagellated spores; that when mosquitoes ingest blood containing these forms the flagellated spores escape in the insect and enter its tissues, where they ripen into some further unknown stage. Then, he thought, the insect dies two or three days later on the surface of the water, and this later stage of the parasites enters the water, and finally rises in the marsh-mist to infect men. Obviously, therefore, Manson's hypothesis was quite different from King's: the former thought that mosquitoes derived the parasite from men and transferred it to the marsh, while King thought just the opposite. Neither really reached the truth: both were half right, but half wrong.

I was first drawn to the malaria problem in the year 1880, when I observed during active service in Burma that the prevalence of malaria did not at all accord with the theory of the telluric and marsh miasma. If the poison is given off in an aerial form, either from water or from soil, the disease ought to be almost uniformly distributed. Such, however, is not the case, and it really occurs principally in very small spots or pockets, generally in close proximity to stagnant water. Thus in one station where I subsequently served my regiment was severely inflicted, while other regiments, scarcely a mile distant, remained almost entirely free.

In 1907 I observed another variety, which I called dappled winged mosquitoes, and which everyone now knows were Anophelines. I first saw these in an intensely malarious quarter near Ootacamund, where I myself acquired malaria during my investigations. A few months later I obtained eight of these insects in Secunderabad, and employed them for my usual experiments. Six of them died or gave bad dissections. On August 20th, 1897, I was so fortunate as to find in the tissues of one of these insects, four days after it had been fed upon a case of malaria, certain bodies which I had never observed in mosquitoes before. These contained the characteristic pigment of the malaria parasite. Next day, the 21st, I found the same bodies in the last mosquito of my batch of eight—only they were now larger and more definite. A little later I found the same bodies in two more mosquitoes and knew that I was on the right track: I felt that the two unknown quantities of this complex equation had been simultaneously found—the species of mosquito which carries malaria, and the position which the parasites take in its tissues, namely, the wall of the intestine.

Unfortunately, my work was now interrupted for nearly six months, just at a point when I expected to unravel the whole history of the malaria parasites in a few weeks; and it was not until March of next year that I was able to take up the thread again in Calcutta. In a very short time I was able to demonstrate the presence in mosquitoes of pigmented bodies derived from the allied parasites. These bodies were found to grow regularly during one week after the insects had been fed; to reach maturity, and to produce a number of elongated spores. Now came an intensely exciting moment. What happens to these spores? According to Manson's hypothesis, they ought to liberate themselves in the water in which the insects died; but I had now shown that the insects did not die after two or three days as he supposed, but may live for weeks. I attempted to follow the spores in all directions through the insects' tissues, into the lower intestine, and even into the egg. On July 4th, 1898, however, I observed the fact that the spores enter the insects' salivary or poison glands. The full truth was now immediately disclosed, and proved to be far more wonderful than any of us had ever dreamed of. The parasites are not only taken from man by the mosquitoes as Manson had supposed and are not only put into man by the mosquitoes as King had supposed; but both hypotheses are true, and the insect carries the parasites directly from man to man. Here then was merely another case of the great law of metaxeny—which, however, was now proved for the first time to hold good for protozoal parasites. The malaria parasites, like many large ones, require two hosts for their life-cycle.

In July and August I infected 22 out of 28 healthy birds by the means of the bites of infected *Culex*—thus completing the whole story in detail. True, that was done with birds' malaria, and I had only seen the first steps of the process with regard to human malaria; but any zoologist will know that with such closely allied species the life-cycle of one is sure to be almost exactly similar to the life-cycle of the other. My work was now interrupted again, and for nearly a whole year; and it was not until August, 1899, that I was able to show directly that the human parasites have exactly the same development. Meantime, however, Koch and Daniels had confirmed my work on birds' malaria; and certain Italian workers repeated it with regard to the human parasites, even to causing infection in healthy human beings (November, 1898), three months after my similar work with birds.

A very important discovery had been meantime made quite independently by MacCallum and Opie in America (1897) who showed that the bodies which Manson had thought were flagellated spores were really sperms. Thus the large pigmented cells which I had found in mosquitoes at the same date were really fertilised macrogametes. This gave a much more correct zoological interpretation to my phenomena; but did not otherwise disturb the history which I had ascertained.

The discovery of the full life-cycle of the parasites enables us, not only to "precise" the route of infection, but to determine exactly which species of mosquitoes are concerned. Since then the work of many observers has shown that out of about 500 Culicidae only about 25 species carry malaria, and that all of these belong to the Anophelines. So that for the prevention of malaria we are not obliged to deal with mosquitoes in general, but only with particular species.

Another discovery, concerned with one of the most important of human diseases—namely, yellow fever, was made by Reed, Carroll, Lazear, and Agramonte during the last days of last century. Without knowing the causative agent of that disease, they yet showed by direct experiments on human beings that the infection is carried directly from man to man by another species of mosquito *Stegomyia fasciata* or *calopus*. It had long been stated by epidemiologists that malaria is connected with damp and decaying vegetation, and the latter with insanitary conditions round houses. The former hypothesis was verified by the observation that Anophelines breed in terrestrial waters, and the latter was now explained by the fact that Stegomyia breed in artificial collections of water round houses. A little

* Abstract from the Huxley lecture, delivered by Sir Ronald Ross, at Charing Cross Hospital.

later Graham gave strong evidence in favor of the theory that dengue fever is carried by a species of *Culex*. Thus mosquitoes have now been incriminated as the carrying agents of no less than four important diseases of man. But this is by no means all. I have mentioned that Bruce incriminated *Glossina morsitans* as the carrying agent of nagana, and he and others now showed that the deadly sleeping sickness of Africa is carried by other tsetse flies. Various Spirochaetes, especially that of tick fever, have been shown to be conveyed by ticks. A peculiar type of comparatively mild fever of which the cause, like that of yellow fever, is still unknown, has been proved to be conveyed by sand flies. Several diseases of animals have been proved to possess a similar history, and others both of animals and men are suspected to lie in the same category. Perhaps, however, the most important and dramatic result was that obtained in the case of plague, the most terrible of epidemic diseases, the wonder and the despair of humanity since the beginnings of history, the scourge which was so often attributed to the direct action of God. It is caused really by the rat flea. And this discovery signals another advance, because plague is, as we all know, due not to an animal but to a vegetable parasite, and we therefore see that bacteria also may adopt precise routes of entry. A similar case is that of Mediterranean fever, which is carried principally by the milk of infected goats; and leprosy (another supposed scourge of Heaven) has been attributed to the bites of bed bugs, while some are even beginning to think that measles is due to fleas.

We now have a great sanitary ideal put before us—so to manage our habitations, villages, towns and cities that the vermin in them shall be reduced to the lowest possible figure. Scores of entomologists and medical men are now dealing exactly with the habits of these creatures and showing us how to effect the required object. It demands only intelligence, energy and organization on the part of administrators. Unfortunately these qualities are not always forthcoming, and administration often lags years behind the dictates of science. Although 15 years have elapsed since many of the facts which I have described were discovered, I think that I may say after constant study of the subject and with all due consideration, that mankind has hitherto not effected more than about one-tenth of the improvement of health which it might have effected already if it had put its heart into the business.

Applied Electrical Science in 1914*

Wide Field Open to Research as an Aid to Practical Application

By Prof. A. E. Kennelly†

The year 1914 will undoubtedly be signalized in the history of our world by two great epoch making events, namely, the opening of the Panama Canal and the opening of the world wide war. Both events may be classified as relating to engineering or applied science, the one being an engineering event of international constructiveness and the other an engineering event of international destructiveness. Both have distinct relations to electrical engineering, and both are doubtless destined to leave their impress upon human affairs for many generations. Nevertheless, we may well hope that in the long run the constructive effects of the canal upon international activities will outweigh the destructive effects of the war.

INFLUENCE OF THE PANAMA CANAL.

The influences of the Panama Canal are manifestly destined to be more potent on civilization than those of the Suez Canal because, to use an electrical analogy, the route short circuited is greater. The Cape of Good Hope lies approximately in south latitude 35 degrees, whereas the Magellan Straits lie in south latitude 5? degrees. By means of the new short-circuit the whole world is virtually made smaller, and the nations of the Pacific are brought into greater relative prominence. Electrical machinery and long distance electrical control, with their concomitant modes of thought, not only actuate the locks of Gatun, but will carry their stimulating influences to all parts of the Pacific. The center of gravity of the world's engineering activities must necessarily undergo some displacement.

THE WAR'S EFFECT ON ELECTRICAL ENGINEERING.

The war has already exercised notable effects upon electrical science. On research, pioneer investigation and all that goes to pave the way for advancing engineering knowledge, it has laid a heavy hand of repression, many young men having been taken from the laboratories of Europe to trenches, fortifications and graves. The influence of this setback is likely to be felt in scientific research for many years to come.

On the other hand, the war itself has had a remarkable influence upon particular branches of electrical engineering, and notably on radiotelegraph engineering. This has been stimulated by the needs of maintaining communication between co-operating forces separated by considerable distance, especially as submarine cables have been intentionally cut in a number of places. Hostile cruisers have commandeered and erected radio stations, while they have also been captured by means of notices sent out through other radio stations. For the first time in the world's history we have witnessed the regular use of radio transmission across the Atlantic by one of the belligerent powers for the dissemination of daily war bulletins. Radio communication has also been employed in the field along the astonishingly long lines running over hundreds of kilometers, while aeroplanes have also been equipped radiotelegraphically. Battle fleets have kept their ships in touch with radio signals, and "jamming" between hostile signalers is now recognized as a regular weapon in the new ethereal warfare. The whole war has depended upon engineering as never before.

This is a gasoline war in which transportation to the armies in the field beyond rail head has depended vitally on automobiles, advances of troops on the ranges of the most improved type of rapid fire cannon, and naval contests on the results of shooting at distances not less than 8 kilometers. It is manifest that next to discipline and *morale* engineering is most important in war.

Another instance of the stimulus which war may give to engineering is afforded by the decision which has been recently announced in the press that, in view of the satisfactory experience last year with the electromagnetic drive on the United States naval collier "Jupiter," the United States Navy Department intends to try electromagnetic variable-speed drive between steam turbines and propellers on a new battleship. On such a ship the demand for high fuel economy over a wide range of speeds is particularly great. Nevertheless, if the electromagnetic drive proves very satisfactory on warships, it may be possible to extend its application to commercial vessels.

IMMENSE FIELD FOR ELECTROMAGNETIC RESEARCH OPENING UP.

Turning to more tranquil themes, the year just passed has witnessed a remarkable development in the electrical theory of the atom. It is only about two years since Dr. Laue discovered the remarkable effects of the interference of Roentgen rays passing through thin crystal plates. This discovery appears to have set ajar the door of a new world, which many pioneers, such as Moseley and Bragg, are rapidly opening.

The world of our immediate recognition may perhaps be described as commencing with the linear magnitudes revealed by the ordinary microscope and ending with the linear dimensions of the earth's diameter, a range in round numbers from a micron or meter-sixth up to some 10,000 kilometers or a meter-seven, a total range of ten million million. Beyond this we recognize a telescopically revealed world of upper magnitudes, commencing say at a meter-seven and going up to what limit we know not, but employing measures of decades of light years, and light is supposed to travel in one of our years through nearly ten millions of millions of kilometers, or a meter thirteen, so that the upper magnitude world may be estimated in round numbers as from a meter-seven to a meter-fifteen, or through an explored range of about one hundred million. There is now opened to our comprehension a third and lower magnitude world commencing say at a micron, where the ordinary microscope stops owing to the relative coarseness of light waves, and descending to we know not what lower limit, but already it is said to an infinitesimal part of a micron, that is, to the X-ray wave length. The world of our immediate cognizance thus comes between an upper magnitude telescopic world with no known upper limit, and the new lower magnitude X-ray microscope world or underworld with no known lower limit. The underworld is also an electrical world in the sense that its dynamics and modes of exploration are essentially electromagnetic. Already the explorers in the underworld are explaining to us from the results of their measurements some of the mysteries of crystalline structure and holding out possibilities as to the yet deeper mysteries of atomic structure. An immense field for electromagnetic research seems to be opening on the borderland between ours and the underworld as the result of discoveries in 1914.

While notable progress has been made in the investigation of extremely short electric waves, progress has also been made during 1914 at the other end of the spectrum, or in the extremely long electric waves of long distance radiotelegraphy. Ranges, powers and wave lengths have all been advancing. Moreover, marked advances have been made in the construction of very high frequency machines for radio communication. It would seem as though the progress of engineering in long-distance radiotelegraphy called for the design of exciters of sustained oscillations in the sending antenna, as distinguished from exciters of oscillations in separate groups.

Steady progress has been witnessed during the year in the direction of the manipulation, control and knowledge of high tension phenomena in relation to transmission lines, including corona losses and over voltages. Energy transmission lines have increased in voltage, number and length.

APPLIED SCIENCE OF ILLUMINATION.

In the applied science of illumination there has been a tendency to increase the use of the lumen or unit of luminous flux and to diminish the use of the candle or unit of luminous intensity. The tendency has been fostered by the difficulty which presents itself in the photometric measurements of certain new types of lamp in which the zonal distribution of light is more than ordinarily complex. In so far as the tendency is parallel to similar movements in the past development of electrics and magnetics, it is presumably to be regarded as an advance.

In the direction of standardization of electrical machinery, the publication by the American Institute of Electrical Engineers of a new edition of its Standardization Rules constitutes a distinct step in advance. The new edition is not only a great improvement upon the old, but it also covers much more ground, owing to the collaboration of many specialists in the various branches of electrical engineering. The new rules have not only presented a fine series of technical definitions, but they also abolish the antiquated preceding notion of an overload capability to be expected in electrical machinery, like a bonus on a stock transaction. The new order of ideas in regard to thermal rating allows of no overloads in regard to temperature, but it establishes clearly the principle that each and every type of electrical machine inherently possesses a certain hottest-spot temperature that should not be exceeded if the particular insulating material entering into the machine is to be preserved from injury. Consistently with maintaining this limit of temperature, the capability of the machine to carry load depends upon the temperature of the machine and the cooling powers of its environments, so that in winter weather with low surrounding temperatures a machine may be capable of carrying considerably more load than in a hot engine room or at a summer temperature. Under specified conditions of ambient temperature the rated load may be obtained.

* Reproduced from *Electrical World*.

† Professor of electrical engineering, Harvard University.

Stereoscopic Photographs

Stereoscopic photography possesses numerous advantages over ordinary photography. Many subjects which in the ordinary photograph are in no way interesting and appear insignificant, have a fresh and surprising charm when standing out in the relief of a stereoscopic photograph. A note in the German journal *Prometheus*, in quoting the *Photographische Rundschau* on this subject, says that the large bare foreground often necessary in photographs of buildings, monuments and the like, enhances the subject of the photograph to a striking degree when that subject is presented in the relief of the double form. The romantic wildness of mountain regions, curious formations of rocks and foaming water-courses make a far stronger impression stereoscopically than in ordinary pictures. The same is true of the many and changing aspects of the sea, as the sea in repose, waves, breakers, effects of sunlight and moonlight on the sea, mirages and reflections caused by light on the water, small boats, ships, etc.

There are excellent kinds of stereoscopic outfits, so that the amateur can obtain these advantages without a very heavy tax on his purse.

New Light on the Great Toothed Divers of America

Remarkable Bird Forms of Prehistoric Times

By R. W. Shufeldt, M. D.*

For many years past the world has known of Prof. O. C. Marsh's discovery of the toothed birds. Their fossil remains showed them to belong principally to two widely separated groups of bird forms, either one of them possessing the extraordinary, though not altogether unlooked for character of true teeth. This discovery was made in 1870, the fossils having been obtained near the Smoky Hill River in western Kansas, the region where we find that geological horizon of the Middle Cretaceous known as the Pteranodon Beds.

As the Cretaceous formation is earlier than the basal Eocene, and the latter having an age of some three millions of years, we may gain some idea of the vast lapse of time since these toothed birds flourished. When they came to be studied and classified they fell into two main genera, the one being represented by *Hesperornis* and the other by *Ichthyornis*. Prof. Marsh's great work about them is now known far and wide throughout the world, and figures of the restored skeletons of *Hesperornis regalis* and *Ichthyornis victor* have been published with text matter about them in nearly every quarter of the globe in several scores of tongues. They have appeared not only in all sorts of scientific books but in every day magazines as well as in school and college text books.

Prof. Marsh made some very unfortunate errors in the sumptuous volume just referred to, for he announced that the Struthious characters seen in *Hesperornis* should probably be regarded as evidence of real affinity, and in this case *Hesperornis* would be essentially a carnivorous swimming ostrich.

This and other statements made by Prof. Marsh in his description of the form in question have since been proved to have been grievously incorrect, for it has been shown beyond all manner of doubt by Prof. D'Arcy Wentworth Thompson of University College (Dundee) and by myself that not only was *Hesperornis* an immense cretaceous diver or loon, but that *Ichthyornis* should never have been compared with a tern (*Sterna*) in order to throw light upon its affinities, for its skeleton shows that it is more nearly related to our black skimmer (*Rhynchops*), as I have pointed out elsewhere long ago. Finally, while Marsh's *restoration* of *Ichthyornis victor* and its near allies is probably quite correct, it is more than can be truthfully said of his restored skeleton of *Hesperornis regalis*, for no bird of its skeletal organization could possibly have stood in any such attitude as he has it. It is ridiculous in the extreme, and it is about time that it be superseded in our text books by a figure presenting the bird, or rather its skeleton, in a natural pose.

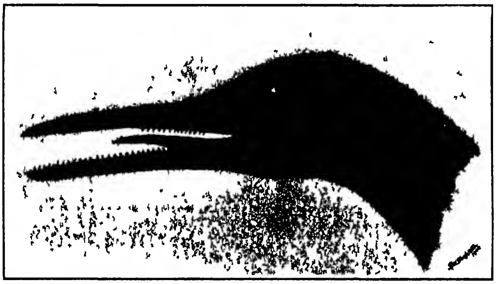

Fig. 3.—Left lateral view of the head of an adult Hesperornis regalis, as it may possibly have appeared in life. Restoration by the author, with proportions taken from a type skull by Marsh

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Fig. 1.—The locality on Dog Creek in Montana where the fossil vertebra of an extinct toothed diver was discovered. Photo by Charles W. Gilmore.

In the United States National Museum there is a mounted restoration of the skeleton and its restored parts which shows very correctly the swimming posture in so far as the skeleton *goes* of this great extinct diver. Mr. Charles W. Gilmore is largely responsible for this excellent piece of work, and it will go a long way toward correcting the gross errors of Marsh in the public mind. No doubt were Prof. Marsh living to-day he would be the first to admit his misconception of the form, habits and relationships of these remarkable birds, and especially those of *Hesperornis*. Moreover, he was not the only one during the latter part of the last century who entertained incorrect notions in regard to these toothed aquatic forms now extinct for nearly four millions of years, for the author of the present article slipped up in several particulars along the same lines.

As long ago as 1890 I published in the *Century Magazine* of New York city an article entitled "Feathered Forms of Other Days," in which numerous figures, reproductions of my own drawings, appeared. Among these was a restoration of *Hesperornis regalis*, which represents the bird perched upon a partially submerged limb in the water. The attitude was suggested by Audubon's figure of the Florida Cormorant, as I have elsewhere said, and this was commented upon, years ago, in my correspondence with the late Prof. Alfred Newton, F.R.S., of Cambridge, England. No *loon* would be likely to climb up on a limb of a sunken tree in any such manner, indeed, as the legs of *Hesperornis* were oar-like paddles that protruded *laterally* from the *sides* of its body, it would have been quite impossible for it to have performed any such feat. As to the tail and feet *per se*, they probably are much nearer the truth. That *Hesperornis* had a big tail composed of true feathers there can be no doubt in the world, while its webbed feet, each possibly having the *contour* of the cormorant's foot, was nevertheless, structurally more likely of the kind we find in any of the great modern divers, such as our great northern diver or loon (*Gavia immer*).

My interest in this subject has been recently revived through what has been brought to my notice from two different sources. The first of these occurred through the kindness of Mr. Charles W. Gilmore, who has charge of the fossil reptile and bird department in the Division of Paleontology in the U. S. National Museum. During the latter part of September Mr. Gilmore and Dr. T. W. Stanton of the Division of Geology of the U. S. National Museum were together exploring the region known as Dog Creek in Fergus County, Montana. They were in search of fossils and were the first scientific explorers to visit that region since Prof. Marsh was there a great many years ago. It was nearly in the exact locality where that geologist discovered the fossil remains of a big bird, which he subsequently named *Coniornis altus*, publishing the fact that he believed it to be allied to the aforesaid *Hesperornis regalis*. In other words that it was a toothed diver related to the extinct cretaceous loons of western Kansas.

The country where this specimen was found is rugged, mountainous and extremely desolate, as will be seen by referring to Fig. 1 of the present article, which is a reproduction of a photograph made by Mr. Gilmore and kindly presented to me for the purpose for which it is now being put. A few months ago I had the opportunity to carefully study the type of Marsh's *Coniornis altus*. The result of my examination will appear later on in another connection, it being somewhat too technical to be touched upon here. This much may be said, however, the bones found by Prof. Marsh belonged to a big toothed diver, and that in itself is extremely interesting, not to say important, for it was generally believed that these extraordinary birds were restricted to a much more limited area, that is, to the Cretaceous Beds of western Kansas.

Now the exploration of Dr. Stanton and Mr. Gilmore in this region was by no means barren of results, for the first named scientist was so fortunate as to discover on Dog Creek, one mile above its mouth on the left hand side of the valley (Fig. 1), the fossil remains of still another large bird, and this valuable material has likewise been submitted to me for description. I find it to belong to a large extinct toothed diver, and is extremely interesting when taken in connection with our studies of *Hesperornis*.

Fig. 2.—Sketch given to show the exact locality of the discovery and the geological formation. By the author.

My research upon this fossil has been completed and fully illustrated. It will appear, later on, in *The Auk*, of which Dr. Witmer Stone is the editor. The exact locality where this fossil was found is shown in Fig. 2 of the present article. The exact spot is there indicated, which is seen to be the bed assigned to the Claggett formation; it is a marine one, and at this point is overlain by the fresh water deposit of the Judith River.

These discoveries go to show that these great ancient

loons with teeth had, in cretaceous time, a very wide range over the country now known to us as western North America, and that there were probably numerous species of them, as I have pointed out in papers which, at the present time, have been accepted for publication.

Hardly had I finished with the discovered material just referred to when I received from my distinguished friend, Mr. Gerhard Heilmann of Copenhagen, the third part of his excellent work now being published on "Our Present Knowledge of the Origin of Birds" in the official Organ of the Danish Ornithological Society. This very thoughtful and painstaking piece of work contains much that is both new and interesting in regard to *Hesperornis*, for Mr. Heilmann is one who is not satisfied unless he goes to the very bottom of things. In my opinion this naturalist's conception of what kind of a bird, including its structure, this giant, cretaceous loon was like now stands among the best of those which have appeared up to date.

As did D'Arcy Thompson and I, or even more thoroughly, Mr. Heilmann has compared the material as given us by Marsh in his *Odontornithes*, representing hesperornis with the corresponding skeletal structures of loons, cormorants and other birds. This exhaustive study convinced Mr. Heilmann that the nearest living allies of the cretaceous loons are the large divers of the present avifauna, as *Gavia* and its near allies in the same family and genus. He is of the opinion that the feet of *Hesperornis* were completely webbed as in the cormorants, which view I do not recall having seen advanced by any American palæornithologist. That the true feather elements are found in the chicks of ostriches and their near allies, the emus, cassowaries, etc., and missing in the adult forms, is excellent evidence pointing to the fact that these now flightless birds are descended from forms which possessed the power of flight as well developed as in any of the best fliers of the present day. As they, in time, lost the power, the plumage *degenerated*, and the wings with the flight feathers atrophied. There can be no question but that all existing birds, whether strong fliers or those in which that power is more or less abrogated, are descended from ancestors which possessed it to the highest degree; for if this were not the case they were never birds at all, but animals of some kind, as those of some reptilian order. A beautiful living example of a bird that is now losing its flight is Harris's Cormorant (*Nannopterum harrisi*) of the Galapagos Island. This bird is a true cormorant which, with its atrophied, degenerated wings, is thoroughly incapable of flight. Its wings have gradually become shrunken from non-use; and, although perfect as wings, they have become useless to the bird for the reason that they are nowhere near large enough for the use of a bird as big and heavy as this cormorant. Its wings were not needed because the bird, being a *fisher*, on lonely islands where it had no enemies, very rarely took to flight, and as a consequence the unused limbs gradually shrunk in size until the bird could not fly, even had it the desire to do so. Recently I prepared an account of the skeleton of this cormorant and it will soon be published by the Zoological Society of New South Wales, Australia. In the plates accompanying it the atrophied wing-bones are well contrasted with the rest of the skeleton and exhibit their diminutive size and feeble development.

When we come to discuss the color of the plumage of *Hesperornis regalis* we not only pass into the realm of pure conjecture, but we are, at the same time, confronted with a question about which very little has been written. All of our now-existing American divers (*Pygopodes*) have white bellies, so it is fair to presume that the entire under parts of *Hesperornis regalis* were white. Mr. Heilmann says "whitish-yellow." Judging from the Great Northern diver (*Gavia immer*) and its near relatives, the Pacific loon, the yellow billed loon and other species, it is almost safe to say that the upper parts were of a bluish or greenish *black*. It is likely, *too*, that the upper parts and neck were longitudinally striped, with stripes composed of squarish or roundish white spots—small on the neck, but increasing in size as they passed to the back and on, diminishing gradually again posteriorly.

The grounds we have for making a surmise of this kind lie in the fact that the young of many birds and mammals present a plumage, or, in the case of the latter, a pelage, which is marked with longitudinal rows of spots, and these are lost when the bird or mammal assumes its adult coloration. This is well exemplified in the young of the loons, the emus, the cassowaries, and, among mammals, the tapirs, the deer, the wart hogs, etc. In some deer the longitudinal spotting remains throughout life, as in the axis deer (*Cervus axis*).

Now, it is a well-established law in phylogeny that very frequently the *young of existing* mammals and birds assume a pelage or a plumage which closely resembles the coloration of the *adults* of their very remote ancestors. This being the case, and especially as the young existing loons are spotted, it is quite or even more than likely that the ancestor, *Hesperornis*, of our present-day loons had rows of longitudinal spots shown its upper parts, and, as I say, on a ground color of a black or a bluish or greenish black.

Mr. Heilmann ably advances this theory in his work; I fail to see any reason for its not having been the case, and a good deal of likelihood that it was. In Fig. 5 of the present article I present a photographic reproduction I made from a plate in his Part III, which was made from his original painting of a group of cretaceous loons (*Hesperornis*), as they may have appeared during the time in which they flourished. Basing it upon conjecture along similar lines, I have also made a drawing of the head of an adult *Hesperornis regalis*, which is here reproduced in Fig. 4. This is somewhat less than the size of nature and was modeled over the skull shown in Fig. 3, which I photographically copied from Marsh's plate, reduced in the same proportion as *Fig. 4* (*Plate XX, Odontornithes*), and which gives the entire skeleton half natural size. In my figures the individual bones are lettered, their names being given in the legend. This has never been done before to the case of this extinct, toothed, cretaceous loon, and I trust it will be of use to comparative avian osteologists.

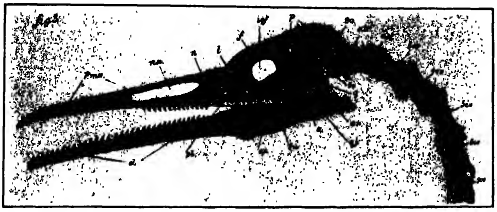


Fig. 4.—Left lateral view of the skull and leading seven cervical vertebræ of Hesperornis regalis; less than half natural size. By the author after Marsh.

Pmx, premaxillary; *n.a.*, nasal aperture; *n*, nasal; *l*, lacrymal; *f*, frontal; *i.o.f.*, interorbital foramen; *p*, parietal; *so*, supraoccipital; *d*, dentary, *pl*, palatine; *sp*, splenial, *su*, surangular; *a*, angular, *qj*, quadrato-jugal; *ar*, articular; *q*, quadrate; *bo*, basioccipital, *at*, atlas or first cervical vertebra, *ax*, axis or second cervical vertebra; *3 cv-7 cv*, the third to the seventh cervical vertebræ, inclusive

Radio-Active Fertilizers

Scientific farmers will be interested in the account given in the *Chemiker-Zeitung* of the experiments made by Prof. Dr. Julius Stoklasa to determine the influence of radio-active fertilizers upon the growth of plants. These experiments were carried on for a number of years partly under glass, partly in fields set aside for the experiments, and included the use both of natural radio-substances (such as masturan from Joachimsthal, water from the same place, and also water from Brambach and Franzensbad) and of artificial solutions (such as chloride of radium). In his earlier experiments Dr. Stoklasa obtained considerable increase in the size of the plants by using determined and not too strong treatments containing nitrate of uranyl and nitrate of lead. Similar experiments were also made by other investigators with "stimulating" or "catalytic" agents, as they were formerly called. Stoklasa then went systematically to work to investigate the radio-activity and made experiments to determine how the activity of a certain bacillus (*Azotobacter chroococcum*), which assimilates elementary nitrogen and converts it into organic forms, is increased by passing radio-active air through its cultural solution. As these investigations yielded positive results he then examined the effect of the emanation upon the higher forms of plant life. It was shown by experiments which were intended to hasten the process of germination that the amount of radio-activity of the water given to the ground in which the experiments were made must vary for different plants, and that to use an unvaryingly fixed strength, in order to obtain an increase of growth, too often resulted in a checking of growth. For example, the amount of non-watery substance gained in one hundred plants was:

	With radio active water.	With water not radio-active.
Pisum arvense	68.73 g.	21.37 g.
Vicia faba	128.87 g.	60.00 g.
Lupinus angustifolius..	37.93 g.	18.45 g.
Hordeum distichum....	90.85 g.	9.08 g.

Of course the decline in the activity, as time went on, of the respective waters was taken into account. During an experiment which lasted 21 days extra increases in non-watery substance of between 62 and 158 per cent were noted in lentils, peas, and wheat. If, though, the water used was too strongly filled with radio-activity 300 to 900 mache units per liter renewed every fourth day—the result was reversed. It can go so far that the leaves become a reddish brown, that is, the chlorophyll is decomposed.

Our investigator found, in particular, in the production of seed that by watering with a radio-water of about 50 to 100 mache units per liter the yield can be increased from 94 to 117 per cent.

Stoklasa also investigated with the aid of glass covers ("emanatoria") the effect of radio-active air upon the development of plants. Using exactly the same soil he surrounded the plants with cylindrical glass-bells into which an emanation was introduced. The result showed that there was a more rapid development of the blossoms in the active air.

These experiments are, therefore, not only most interesting from a scientific point of view, but have also great practical value. Agricultural experiments with radio-active fertilizers have been made before this, but it would seem that the most of such work must still be left for a time to the experimental stations. At the present moment it only pays to use such a fertilizer where the nature of the soil is suitable in itself. Our investigator says further that the radio-active treatment must be adjusted to the nutritive substances of the soil and to the general constituents of vegetation.

An Electrically Driven Warship

As a result of the successful operation of the electric power system in use on the U. S. naval collier "Jupiter," it has been announced by the Navy Department that the same general system will be installed in the new super-dreadnought "California." This will be the first electrically driven warship, and it will have a minimum speed of 21 knots.

Fig. 5.—A group of cretaceous loons (Hesperornis regalis) as they appeared three or four million years ago. Restoration by Gerhard Heilmann of Copenhagen, and reproduced from a photograph by the author.

Military Surgery

Some Lessons Taught by the Present War

By Our Berlin Correspondent

Dr. Payr the celebrated Leipzig surgeon recently delivered a remarkable lecture before the war correspondents of the Germany army on his personal experience in the field. He has from the very beginning of the war devoted to the military authorities the whole of his time and his exceptional knowledge and in his capacity as General Surgeon to the Saxon army he has been in a position to collect the most valuable experience. In fact his lecture of which an abstract is given in the following may be considered as the most authoritative statement yet made public on the lessons taught by the present war in the field of military surgery.

The learned professor at first cautioned his hearers against the many drawbacks of military surgery. There was primarily the difficulty of watching the course of a given case, patients being often lost sight of two or three days after an operation so that the success of the latter cannot always be ascertained. Further there is a risk of the surgeon being hampered in his work by sheer scrupulousness, antiseptic conditions being of course far less satisfactory than at home in his own clinic. Another risk finally is the unavoidable rush of work which may induce the surgeon to proceed to operation without mature consideration of actual circumstances.

The projectiles concerned in the case of bullet-wounds are infantry projectiles, shrapnel bullets, shell fragments, bomb fragments and aeroplane arrows. To these should be added dumdum projectiles, bullets deflected from their original course and what might be termed indirect projectiles, viz., fragments of clothing, coins and other objects from the soldier's pockets which have been forced into the wound. The effect of projectiles mainly depends on their percussive force, size, shape, material, direction and goal, as well as on the number, firmness and tension of the organs struck.

The aeroplane arrow is a new weapon which has made its first appearance in the present war. It is a steel rod of the thickness of a pencil with pointed shaft. The rear end is grooved out square so that the point is heavier than the end. As an arrow such as this falls vertically to the ground from a height of, say, 1,500 meters it will reach a speed of 200 meters per second, which is equivalent to the velocity of a rifle bullet. In fact the wounds made by these arrows are very serious.

According to an old classification the lecturer distinguishes several categories of shots: Ricochets, when the projectile does not penetrate into the body; embedded shots ("Steckschüsse") when the projectile sticks fast in the body, and piercing shots ("Durchschüsse") when the projectile pierces the body and comes out at the other end. The degree of harm done to the tissues and organs obviously depends on a number of accessory circumstances. It was thought in former times that blood vessels could bend out of the way of projectiles. However modern infantry projectiles have been found to penetrate right through the vessels, even small arteries whose diameter does not exceed that of a quill being pierced. This is why a far greater number of artery lesions have to be dealt with in the present war.

Wounds made by modern projectiles in bones and joints are of especial importance. At short range bones will be shattered into a number of fragments. As the distance increases there is a growing tendency for the projectiles to pierce the bone and just to produce one or two cracks in the neighborhood of the hole. The long tubular bones which are hard as ivory will be split even at very considerable distances, say 1,600-1,800 meters, whereas bones of a more spongy texture, such as the joint of the knee, are pierced smoothly. This is why shots through the joints take a relatively benign course.

The possible effects of shot-wounds are hemorrhage, pain, shock, mutilation and death. As regards pain it is obviously among the foremost duties of the surgeon in war to see that the wounded may as soon as possible get the benefit of alleviating remedies. The general practice now is to administer at the earliest possible moment a morphine injection.

Modern warfare is liable to result in a special abundance of wounds of the head, soldiers on firing from the trenches having to advance their heads. There are two distinct types of head shots, viz., on one hand embedded and piercing shots, in the case of which the bullet traverses the head directly or sticks fast in the skull or brain, and on the other tangential or "groove" shots, when the projectile as it were plows a groove through the skull bone. Tangential shots should be treated differently from embedded and piercing shots, bone fragments severed by the bullet producing practically always serious infection.

Most shots through the neck are benign, though there are some vital organs concerned, blood vessels, nerves, spinal marrow, and the oesophagus and windpipe. If the windpipe and larynx are affected, operation should be proceeded with as promptly as possible, thus preventing any risk of stifling.

Shots through the chest are, of all shots dealt with in modern warfare, those most easily treated. The Japanese used to say that their men in the case of simple breast shots could return to the firing line after a week or so. According to German experience in the present war such patients, even in case the lungs have been pierced, will at least be transportable after ten to fourteen days. Though they may for some days go on coughing out blood, they will in no way be inconvenienced as far as their general condition is concerned. If the heart or aorta has been struck, the surgeon's aid of course is of no avail, such patients being brought in too late from the battle-field. Whereas in time of peace it is quite feasible to remove a projectile from the heart, saving the patient's life by a heart suture, any attempt at such an operation in warfare would be futile. As it is, modern projectiles are doubtless more humane in their effects than the lead bullets of old, and provided the ribs have not been injured the wounded can after quite a short time be restored to full fighting ability.

Shots through the abdomen are an item much discussed in modern war surgery. In time of peace it is an absolute rule to operate as soon as possible by means of a cut through the abdomen, thus staying the blood, and by opening part of the stomach and the intestines to make the wound inoffensive and prevent any infection liable to result in peritonitis. Already the South African war, however, has shown such shots to be more benign in case operation is foregone. In fact there are a number of instances in the present war in which good results were obtained by a very simple treatment, the patient being kept for a week absolutely quiet and without food or drink. When this limit was not observed the condition of the patient would invariably become worse.

The lecturer next proceeded to answer the question as to how bullet wounds should be treated. According to the best German practice the following principle is adopted: A certain amount of infection should be in any case accounted for, which cannot be reduced by any measures whatever. If a patient has for instance received a shot through the arm, a certain number of microbes have penetrated into the wound which it would be impossible to reduce. Rinsing the wound with water or rubbing it with antiseptics, so far from being of any avail, has been found to be harmful, the antiseptic liquid diminishing the vital strength of the tissues. However, no new noxious agents should be added to those microbes. Experience shows that healthy subjects will deal with a given number of bacteria provided no further germs are allowed to enter the wound. This is the principle controlling the first phase in the treatment of the wounded. The surroundings of the wound are no longer washed and cleaned with soaps as once upon a time, but a piece of aseptic gauze is applied to the wound such as is contained in the roll of bandage carried by every German soldier and officer in the field. The first dressing is thus applied, which the men themselves or their comrades are trained to do very cleverly.

Another method to prevent the microbes from multiplying is what is termed the arresting process. The parts round the wound are brushed over with tincture of iodine or mastisol. The microbes are fixed by mastix, another advantage of this process is that the aseptic gauze is attached to the wound, thus preventing the dressing from being shifted. These methods have given excellent results.

Provision must, of course, be made for the wounded to undergo long and difficult transports, especially in the case of injury to the bones and joints. Splints have often to be improvised. In fact, the surgeon in time of war, must show much ingenuity in making shift with anything happening to be at hand. The wood of a young tree, sticks, etc., are, for instance, used as splints, but practical splints have also been made from braided straw.

The final treatment of wounds comprises a number of other problems, but a point should be made of avoiding too much zeal. The wound being well dressed and covered with aseptic gauze, there is no need for the whole bandage being exchanged, it being sufficient to renew the outer dressing. Wounds on which the first dressing—made from the man's own dressing materials—had been left, were found after a week to be healed. The greatest care should in any case be used in renewing the bandage, lest any microbes be allowed to penetrate into the wound. Cuts through the windpipe and the tying up of pierced blood vessels should, of course, be made on the very battle-field, whereas the decision as to whether any wounded members should be amputated must be left to the further treatment.

No importance is now attached to the removing of projectiles if the latter cause no inconvenience. This is true of infantry projectiles. According to the lecturer's experience, the German steel sleeve projectile, for some unknown reason, is more humane than the French copper alloy projectile which frequently causes pain. Shrapnel bullets, which are round, have far less impact and percussive force than infantry projectiles. Penetrating into the deeper parts of the body, along with such foreign bodies as pieces of clothing, etc., they are apt to produce suppuration. In 70 to 75 per cent of shrapnel wounds under treatment, suppuration has been observed, a slight quantity of chocolate-colored liquid coming out of the wound as this is opened. Shell fragments likewise carry along foreign objects and thus give rise to suppuration, they must therefore be removed.

Artillery wounds, which are so frequent in the present war and which by no means take an always benign course, are a danger of their own. They give rise to suppuration of the tissues, gas phlegmons and tetanus. Good results have in many cases been obtained with the inoculation of a tetanus serum.

Personally, the lecturer was able to record a number of striking successes in his surgical practice during the first months of the war. Ordinary shots through the fleshy parts of the members nearly always take a very gratifying course. In many cases the men were restored to fighting ability after a week, though they had only been treated with the dressing material contained in the small parcels carried by each soldier. Infantry bullet shots through joints would take a very benign course if the wound was treated aseptically and, if required, dressed in splints shortly after the injury.

The effects of aeroplane bombs are very much different from those of bursting shells, the injuries even produced by small fragments being so extremely serious as never witnessed by Dr. Payr in the case of shell fragments. Another unpleasant feature of aeroplane bomb fragments is their cutting like knives deep into the members and there piercing the vessels.

Employment of War Prisoners

Sixty thousand prisoners of war have now been assembled at the Münster camp on the Lüneburg Heath, states *Vorwärts*, where they are cultivating the waste lands. The majority of the men are French, though there is also a number of Belgians, Russians and English in the camp. Many previous attempts had been made to cultivate this huge tract of moorland country which is well known to travelers between Hamburg and Berlin, but the chronic scarcity of agricultural laborers in peace time had always hindered the project. The local authorities of Hanover accordingly appealed to the military administration to make use of war prisoners for this purpose, and the permission was at once given.

One example may be given (says *Vorwärts*) of the manner in which the work is proceeding. In the district of Neustadt, near Hanover, the cultivation of the so-called Rodewalder Bruch had long been contemplated. The District Council purchased a large tract of this country, which, with the help of 2,000 prisoners of war, is being broken up and made ready for cultivation. In due course it will be divided up into thirty farm estates. Barracks for the prisoners are being built largely by the aid of the captives themselves, but later on these buildings can be used as cattle sheds and corn stores. The new colony has been christened Lichtenhorst, and if the winter is favorable it is hoped to have the work so far advanced that the first crops can be sown next spring. In this case Hanover will next year have many hundred acres of new land under cultivation with wheat, potatoes, etc.—*London Daily Telegraph.*

An Experiment in Forestry.

The Laurentide Company of Quebec, producers of pulp and pulpwood, is trying an interesting experiment in reforesting its non-agricultural cut-over lands. It is also importing reindeer from Newfoundland to see if they can take the place of dogs in winter woods work.

Installation of a Gas Engine*

Points to be Observed in Buying, Transporting, Placing and Starting

There are a number of points that should be considered before purchasing a gas engine one of which is the amount of power required for the work to be done. It is generally advisable no matter what style of engine is to be purchased, to buy a unit somewhat larger than may at first seem necessary. It is always well to have some power in reserve because an engine working under an excessive load is inefficient and involves a money loss to the owner on account of the wear and tear on the engine.

The style of engine to be used is determined by the location and the nature of the work to be performed. If the engine is used in a fixed location a stationary type should be selected whereas the portable type and the traction engine must be selected when the engine is for use at various points and when loads are to be hauled. The selection of the right type is fully as important as the selection of the right make also while attractive paint and a high polish are desirable these tell very little of the real value of the engine.

When repairs are necessary the importance of having an engine which has been standardized is fully realized by the purchaser. Repair parts should be obtainable at convenient points within a few hours because delays in waiting for repair parts usually prove expensive.

It is important to bear in mind that the rated horse-power of an engine is not always a reliable basis for comparison with the actual power that the engine will deliver. There are many gas engines on the market rated at five horse-power for example that will hardly have a maximum output of as much as five horse-power under regular operating conditions. Again there are engines built by reputable manufacturers that deliver continually an overload of as much as 20 per cent above their rating. If there is any doubt in the mind of the purchaser as to the power that it is possible to obtain from an engine he should insist upon proofs of the actual brake horse-power.

When the engine has been purchased the next thing to consider is where it is to be placed. In selecting the position for the engine note that it ought to be placed in the cleanest driest and lightest spot obtainable. If it is to be belted to machinery that is already in place it is necessary to decide where the flywheel will be located and the foundation should be made with this in mind. If the machinery is to be installed later, suitable position for it must be determined at the time the engine is installed in order to insure that no difficulties will be met with in transmitting the power. If the engine is installed in a large room a small room or space should be partitioned off around it in order to keep out dust and dirt. Under all circumstances, never allow a gas engine or any other engine for that matter to run in the same room with emery or polishing wheels.

Assuming the engine to be of the stationary type the purchaser should obtain a templet and anchor bolts generally furnished with each engine. The templet is a wooden frame of the size of the bottom of the base of the engine having holes in it to match the holes in the base of the engine frame.

THE FOUNDATION

The dimensions of the foundation at the bottom should be at least twice the length of the engine base and not less than two and one half times the width and the depth of the foundation should be equal to its length. The shape of the foundation is then made in the form of a frustum of a pyramid sloping up toward the top where it is only about three inches larger on all sides than the base of the engine. When the hole has been dug in the ground a form for the concrete must be made and then the concrete is mixed as follows one sack of good cement, two wheelbarrows of sand and three wheelbarrows of crushed rock or small gravel well mixed with water to make it easy to handle. When putting the concrete into the form it is advisable to use old scrap iron of all kinds chains wire etc to reinforce the concrete and keep it from cracking. Put in the concrete and scrap iron together, tamping it tightly into the form. Before putting in the concrete however place the anchor bolts in the bottom of the hole, with large heavy washers on their heads, and use the templet to locate them properly at the bottom then run the nuts down on the anchor bolts far enough to allow the templet to rest upon them while locating the bolts at the top at about the level where the engine will be set on the foundation. Then fasten the bolts in some way so that they will not move while the concrete is being put in place. The wooden templet is left on the top of the foundation, the nuts, of course, being removed when the foundation reaches them and the engine is set on the top of the templet as it is advisable to use a thin strip of wood between the concrete and the cast iron of the base. The foundation should be left to set at least four days before the engine is placed on it.

REMOVING AN ENGINE FROM A RAILROAD CAR

The foundation now being ready we will assume that the engine has arrived in a railroad car at the station and that it is to be removed from there by the purchaser. A few points relating to this operation will prove of value. The engine has been delivered to the transportation company by the manufacturer or dealer properly packed for shipment. The responsibility of the manufacturer or agent stops at this point and the transportation company is supposed to deliver it to the purchaser in perfect condition. The engine if of a heavy type has been transported in a separate car and is left on a side track accessible for teams. The first thing to do is to have the local station agent make an inspection of the engine in the presence of the purchaser or his representative to see if it is in good condition and that no damage has been done to it in transportation. Should any damage be revealed at this inspection the station agent should be required to make a notation of the damage upon the expense bill before the freight is paid. After this is done the transportation company is liable for the damage if any and the buyer is safe in unloading and taking charge of the engine.

If any timbers or assistance are needed in unloading the engine from the car the transportation company through its agent is supposed to furnish them. If the transportation company furnishes bad timbers for this purpose and an accident is caused thereby the mere acceptance by the purchaser of the bad timbers does not place the responsibility upon him. The engine should preferably be moved onto a flat top dray wagon without springs. In moving the engine take care to see that it is properly supported at all times and see where each step in the moving is going to leave it. If any accident happens to the engine before it is clear of the car or before it is taken off the skids conveying it from the car to the wagon the transportation company is liable for the damage because being a local shipment the company is supposed to remove it from the car and the purchaser is merely acting for the company when taking the engine from the car. After the engine is placed on the wagon the purchaser is entirely responsible for it.

As an example of what may be encountered in unloading an engine the following experience may be mentioned. An engine arrived at its destination in good condition and the car was set on a siding near a pile of ties that were to be used in unloading. Some other timbers were also necessary which the agent of the railroad company furnished but these were not as strong as the man unloading the engine required however the station agent informed him that he would have to use them. He went on with the operations taking extra precautions to brace the weak timbers but just as the engine was about half way between the car and the wagon one of them gave way and the engine went into a ditch upside down. The man in charge of the unloading went to the long distance telephone and called up the general agent of the manufacturing company stating the circumstances and asking for instructions. He was told to inform the station agent that the engine could not be used and that it would be left on the railroad company's hands. A new engine was loaded at the factory the same day and shipped and in that case ample assistance was rendered in unloading the new engine. The first engine was loaded by the railroad company onto a car and returned to the factory free of charge the bill for the necessary repairs was rendered to the railroad company and was paid without a damage suit.

After the engine is safely placed on the wagon it should be conveyed by the safest and easiest road to the place of installation. Avoid uneven ground and bad street crossings take plenty of time and be sure of every move. Always release the team from the wagon while loading and unloading the engine. The unloading is greatly simplified if two trenches are dug for the wheels of the wagon so that the axles almost touch the ground. In this case the timbers on which the engine is handled will be more nearly level. If they are entirely level rollers may be used under the skids to which the engine is fastened. If however the timbers slope at all rollers should not be used. The main thing is to avoid haste, and not to permit anything to interfere until the engine has been placed on the foundation.

INSTALLATION OF AUXILIARIES

The next thing is to select a suitable place for the battery box. This place should be dry and free from vibration. The wiring is now connected. If natural gas is to be used as a fuel it is necessary to have a special mixer which will be furnished by the manufacturer of the engine. All that is necessary is a gas bag or tank and piping to allow the charge to be drawn quickly into the cylinder. Some engines use gasoline for a start and then switch onto the natural gas while others start directly on the gas. If the engine will start on the gas there is no reason for using gasoline.

If liquid fuel is to be used it is advisable to place the fuel tank outside the building and it is still better to bury it in the ground. After the tank has been buried in a suitable place it is an easy matter to arrange the piping to the fuel pump on the engine. As far as possible this piping should be underground as it is out of the way. A pipe for the fuel passing from the pump to the mixer and a pipe for the overflow to return from the mixer bowl to the tank must be provided. If the overflow pipe stops at the top of the fuel tank it will not be necessary to have a vent hole at the top of the tank as the air will flow into the tank from the overhead pipe which will not always be full of gasoline. The pump pipe should pass to the bottom of the tank and should be provided with a light screen to prevent foreign substances from passing into the mixer.

STARTING A NEW ENGINE

After the engine is properly installed the first thing is to start it running. This is done by turning on the battery switch setting the needle valve in the starting position turning off the air damper releasing the compression and giving the flywheel a few turns which will put it in motion. After the engine has made a few revolutions open the air damper close the needle valve to the running position put the relief cam back into place and let the engine run watching for developments. It is of course presumed that all the oilers and grease cups have been filled and that all movable parts have been oiled with the oil can. Now see that water enters the cylinder cooling jacket within five minutes or stop the engine as it is not safe to allow it to run without cooling water on the jacket. It is best to allow the engine to run an hour or so without any load and to watch the bearings to see that they do not become overheated. In case of doubt on any point stop the engine and examine it.

In cold weather a gasoline engine is more difficult to start than in warm weather the reason being that gasoline in changing from a liquid to a vapor reduces its temperature about 30 deg Fahr. If the air is cold on the outside of the cylinder and the mixer has taken in vapor 30 degrees colder it is easy to understand that this would interfere with the proper vaporization. Hence it will be difficult to start the engine. There are several methods of overcoming this difficulty either by warming the gasoline warming the air or by using one part ether and four parts gasoline for a start this will make a liquid that will vaporize readily several degrees below zero. To warm the gasoline is a process which is dangerous and should only be attempted as a last resort. It can be done safely only by using hot water or a hot cloth. The air may be warmed by heating a piece of iron red hot and holding it at the mouth of the intake pipe allowing the air to pass over it as it goes into the intake pipe after which it joins the gasoline vapor and heats it.

* Reprinted from Machinery. From an article prepared [illegible] by J. L. Hobbs, gas engine expert.

Motor Fuel in Germany

A very large proportion of the supplies of gasoline used by motor cars in Germany has been obtained from the United States as well as considerable quantities from Russia, and the East Indies. It is believed that these sources of supply have now been effectively cut off, so that outside of accumulated stock the wells of Gallacia are the only ones from which fuel supplies of this class can be obtained and these wells can be depended on for little more than crude oils and these in no great quantities. It is reported that alcohol and benzol are used exclusively by the cars in the military service, but the supply of alcohol must be limited, as the grain, potatoes etc., from which it is made will undoubtedly soon be required for food purposes and it is doubtful if the supplies of benzol are anywhere near sufficient. In a machine-made war such as the present one pre-eminently is the question of a supply of motor fuel is a most important item, and it will be interesting to see how Germany will solve the problem.

A Great Railway Electrification Project

440 Miles of the Chicago, Milwaukee & St. Paul Mountain Lines to be Operated by Electric Power

The Chicago, Milwaukee & St. Paul Railroad has decided to electrify four engine divisions of its Puget Sound lines, extending from Harlowton, Montana, to Avery, Idaho, a total distance of about 440 miles, aggregating approximately 650 miles of track, including yards and sidings.

Work has already been started on the first engine division, consisting of 113 miles of main line track between Three Forks and Deer Lodge, Montana, and contracts have been let to the General Electric Company for the electric locomotives, substation apparatus and line material. Power will be secured from the Montana Power Company, which will also construct the transmission and trolley lines.

While the four engine divisions of 440 miles comprise the extent of track to be equipped in the near future, it is understood that plans are being made to extend the electrification from Harlowton to the coast, a distance of 850 miles, should the operating results of the initial installation prove as satisfactory as anticipated.

The plans of the Chicago, Milwaukee & St. Paul Railway are of especial interest, as this is the first attempt to install and operate electric locomotives on tracks extending over several engine divisions, under which condition it is claimed the full advantage of electrification can be secured. The various terminal and tunnel installations have been made necessary, more or less by reason of local conditions; but the electrification of this road is undertaken purely on economic grounds with the expectation that superior operating results with electric locomotives will effect a sufficient reduction in the present cost of steam operation to return an attractive percentage on the large investment required. If the anticipated savings are realized in the electric operation of the road this initial installation will constitute one of the most important milestones in electric railway progress, and it should foreshadow large future developments in heavy steam road electrification. The success of electric operation on such a large scale will, at least, settle the engineering and economic questions that enter into the advisability of making such an installation, and will limit similar future problems to the means of raising the money expenditure required.

The first step taken toward electrification by the Chicago, Milwaukee & St. Paul Railway was to enter into a contract with the Montana Power Company for an adequate supply of power over the 440 miles of main line considered for immediate electrification. The precautions taken, both by the railway company and power company, to safeguard the continuity of power supply should guarantee a reliable source of power subject to few interruptions of a momentary nature only.

The Montana Power Company covers a great part of Montana and part of Idaho with its network of transmission lines, which are fed from a number of sources of which the principal ones are tabulated below:

Madison River	11,000 kilowatts
Canyon Ferry	7,500 kilowatts
Hauser Lake	14,000 kilowatts
Big Hole	3,000 kilowatts
Butte, steam turbine	5,000 kilowatts
Rainbow Falls	21,000 kilowatts
Small powers aggregating	7,390 kilowatts
Total power developed	68,890 kilowatts

Further developments, part of which are under construction, are as follows:

Great Falls	85,000 kilowatts
Holter	30,000 kilowatts
Thompson Falls	30,000 kilowatts
Snake River	20,000 kilowatts
Missoula River	10,000 kilowatts
Total	175,000 kilowatts
Total power capacity, developed and undeveloped	244,000 kilowatts

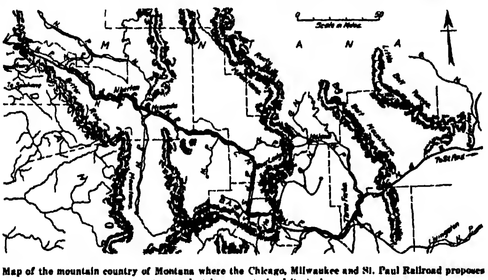
The several power sites are interconnected by transmission lines supported on wooden poles and operating at 50,000 volts for the earlier installations, and on steel towers and operating at 100,000 volts for later installations. Ample water storage capacity is provided in the Hebgen reservoir of 300,000 acre feet, supplemented by an auxiliary reservoir capacity at the several power sites, which brings the total up to 418,000 acre feet. The Hebgen reservoir is so located at the head waters of the Madison River that water drawn from it can supply in turn the several installations on the Madison and Missouri rivers, so that the same storage capacity is used a number of times, affording an available storage capacity considerably greater than is indicated by the figures given. It would seem, therefore, in changing from coal to electricity as a source of motive power, that the railroad is amply protected in respect to the reliability and continuity of the power supply.

Due to the great facilities available and the low cost of construction under the favorable conditions existing, the railway company will purchase power at a contract rate of 0.00536 cent per kilowatt-hour, based on a 60 per cent load factor. It is expected, under these conditions, that the cost of power for locomotives will be considerably less than is now expended for coal. The contract between the railway and power companies provides that the total electrification between Harlowton and Avery, comprising four engine divisions, will be in operation January 1st, 1916.

In order to connect the substations with the several feeding-in points of the Montana power transmission lines, a tie-in transmission line is being built by the railway company that will permit feeding each substation from two directions and from two or more sources of power. This transmission line will be constructed with wooden poles, suspension type insulators, will operate at 100,000 volts, and will follow, in general, the right of way of the railway company except where advantage can be taken of a shorter route over public domain to avoid the necessarily circuitous line of the railway in the mountain districts.

The immediate electrification of 113 miles will include four substations containing step-down transformers and motor generator sets with necessary controlling switchboard apparatus to convert 100,000-volt, 60-cycle, three-phase power to 3,000 volts direct current. This is the first direct current installation using such a high potential as 3,000 volts, and this system was adopted in preference to all others after a careful investigation extending over two years. The 2,400-volt direct current installation of the Butte, Anaconda & Pacific Railway in the immediate territory of the proposed Chicago, Milwaukee & St. Paul electrification has furnished an excellent demonstration of high-voltage, direct-current locomotive operation during the past year and a half, and the selection of 3,000 volts direct current for the Chicago, Milwaukee & St. Paul was due, in a large measure, to the entirely satisfactory performance of the Butte, Anaconda & Pacific installation.

The equipment for this road was also furnished by the General Electric Company, and a comparison based on six months' steam and electric operation shows a total net saving of more than 20 per cent on the investment or total cost of the electrification. These figures, of course, do not take into account the increased capacity of the lines, improvement to the service, and the more regular working hours for the crews. The comparison also shows that the tonnage per train has been increased by 35 per cent, while the number of trains has been decreased by 25 per cent, with a saving of 27 per cent in the time required per trip.



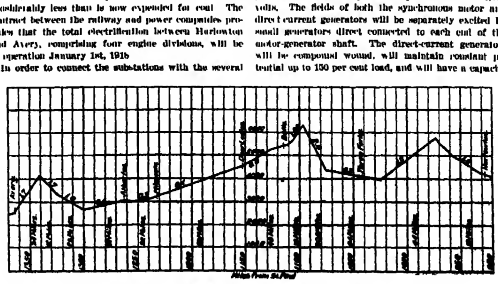
Map of the mountain country of Montana where the Chicago, Milwaukee and St. Paul Railroad proposes to use electric power to haul its trains.

SUBSTATIONS.

The substation sites of the Chicago, Milwaukee & St. Paul electrified zone provide for an average intervening distance of approximately 35 miles, notwithstanding that the first installation embraces 20.8 miles of 2 per cent grade westbound and 10.4 miles of 1.66 per cent grade eastbound over the main range of the Rocky Mountains. With this extreme distance between substations and considering the heavy traffic and small amount of feeder copper to be installed, it becomes apparent that such a high potential as 3,000 volts direct current permits of a minimum investment in substation apparatus and considerable latitude as to location sites.

The substations will be of the indoor type, transformers being three-phase, oil-cooled, and reducing from 100,000 volts primary to 2,300 volts secondary, at which potential the synchronous motors will operate. The transformers will be rated 1,800 and 2,500 kilovolt-amperes and will be provided with four 2½ per cent taps in the primary and 50 per cent starting taps in the secondary.

The motor generator sets will comprise a 60-cycle synchronous motor driving two 1,500-volt, direct-current generators connected permanently in series for 3,000 volts. The fields of both the synchronous motor and direct-current generators will be separately excited by small generators direct connected to each end of the motor-generator shaft. The direct-current generators will be compound wound, will maintain constant potential up to 150 per cent load, and will have a capacity



Profile of the route in above map, showing grades and distances.

Through Jefferson Valley Montana.

Skirting the mountain tops near Jefferson Valley

Pulling over a heavy grade in the Rocky Mountains

Tunnels and bridges in Sixteen Mile Canyon Belt Mountains

The east slope of the Bitter Root Mountains.

The devious trail through the Bitter Root Mountains

On a two per cent grade in the mountains of Montana

Raton Falls which will supply part of the electric power

SCENES IN THE REGION IN WHICH THE CHICAGO MILWAUKEE AND ST PAUL RAILROAD WILL USE ELECTRIC POWER

for momentary overloads up to three times their normal rating. To insure good commutation on these overloads, the generators are equipped with commutating poles and compensating pole-face windings. The synchronous motors will also be utilized as synchronous condensers, and it is expected that the transmission line voltage can be so regulated thereby as to eliminate any effect of the fluctuating railway load.

The location and equipment of the several substations is as follows:

Station	Miles from Deer Lodge	No. of units	Kw. per unit	Total
Morel	17.1	2	2 000	4 000
Janney	50.5	3	1 500	4 500
Piedmont	77.9	3	1 500	4 500
Eustis	120.6	2	2 000	4 000

OVERHEAD CONSTRUCTION

The trolley construction will be of the catenary type in which a 4/0 trolley wire is flexibly suspended from a steel catenary supported on wooden poles, the construction being bracket wherever track alignment will permit and cross span on the sharper curves and in yards. Steel supports instead of wooden poles will be used in yards where the number of tracks to be spanned exceeds the possibilities of wooden pole construction. Poles for the first installation are already on the ground and thirty miles of poles are set. Work in this direction will be pushed with all speed and will be completed in the summer of 1915 ready for operation in the fall on the delivery of the first locomotives.

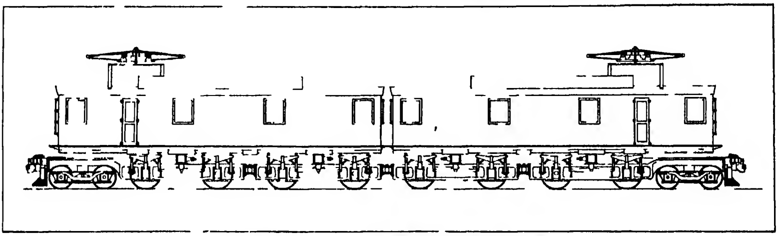
As the result of careful investigation and experiments a novel construction of trolley will be installed composed of the so-called twin conductor trolley. This comprises two 4/0 wires suspended side by side from the same catenary by independent hangers alternately connected to each trolley wire. This form of construction permits the collection of very heavy current by reason of the twin contact of the pantograph with the two trolley wires and also insures sparkless collection under the extremes of either heavy current at low speed or more moderate current at very high speeds. It seems that the twin-conductor type of construction is equally adapted to the heavy grades calling for the collection of very heavy currents and on the more level portions of the profile where maximum speeds of 60 miles per hour will be reached with the passenger trains having a total weight of over 1 000 tons. The advantage of this type of construction is due partly to the greater surface for the collection of current but largely to the very great flexibility of the alternately suspended trolley wires, a form of construction which eliminates any tendency to flash at the hangers either at low or high speed. Including sidings, passing and yard tracks, the 113 miles of route mileage is increased to approximately 168 miles of single track to be equipped between Deer Lodge and Three Forks in the initial installation.

LOCOMOTIVES

The locomotives to be manufactured by the General Electric Company are of especial interest for many reasons. They are the first locomotives to be constructed for railroad service with direct current motors designed for so high a potential as 3 000 volts. They will weigh approximately 260 tons and will have a continuous capacity greater than any steam or electric locomotive yet constructed. Perhaps the most interesting part of the equipment is the control, which is arranged to effect regenerative electric braking on down grades. This feature as yet has never been accomplished with direct-current motors on so large a scale. The general characteristics as proposed are tabulated below:

Total weight	260 tons
Weight on drivers	200 tons
Weight on each guiding truck	30 tons
Number of driving axles	8
Number of motors	8
Number of guiding trucks	2
Number of axles per guiding truck	2
Total length of locomotive	112 feet
Rigid wheel base	10 feet
Voltage of locomotive	3,000
Voltage per motor	1,500
Horse-power rating 1 hour each motor	430
Horse-power rating continuous each motor	375
Horse power rating 1 hour complete locomotive	3 440
Horse-power rating continuous complete locomotive	3 000
Trailing load capacity 2 per cent grade	1 250 tons
Trailing load capacity 1 per cent grade	2 500 tons
Approximate speed at these loads and grades	16 m.p.h.

The Chicago Milwaukee & St. Paul Railway from Harlowton to the coast crosses four mountain ranges. The Belt Mountains at an elevation of 5 768 feet, the Rocky Mountains at an elevation of 6,350 feet, the Bitter Root Mountains at an elevation of 4 200 feet and the Cascade Mountains at an elevation of 3 010 feet. The first electrification between Three Forks and Deer Lodge calls for locomotive operation over 208 miles of 2 per cent grade between Piedmont and Donald at the crest of the main Rocky Mountain Divide, so that 2 per cent ruling grades on the west and east slopes of the Rocky Mountain Divide with the help of a second similar freight locomotive acting as a pusher. Track provision is being made at Donald, the summit of the grade, to enable the pusher locomotive to run around the train and be coupled to the head end to permit electric braking on the down grade. In this case, the entire train will be under compression and held back by the two locomotives at this head end, the entire electric braking of the two locomotives being under the control of the motorman in the operating cab of the leading locomotive. It is considered that electric braking will prove very valuable in this mountain railroading for in addition to providing the greatest safety in operation it also returns a considerable amount of energy to the substations and transmission system, which can be utilized by other trains demanding power. In this connection the electric locomotives will have electric braking capacity sufficient to hold back the entire train on down grade leaving the air brake equipment with which they are also equipped to be used only in emergency and when stopping the train. There is therefore provided a duplicate braking system on down grades which should be reflected in the greatest safety of operation afforded and the elimination of a considerable part of break downs, wheel and track wear



3 000 volt direct current electric locomotive. Most powerful yet built

the locomotives will be fully tested out as to their capacity and general service performance in overcoming the natural obstacles of the first engine division.

The initial contract calls for nine freight and three passenger locomotives having the above characteristics and similar in all respects except that the passenger locomotives will be provided with a gear ratio permitting the operation of 800-ton trailing passenger trains at approximately 60 miles per hour and will furthermore be equipped with an oil fired steam heating outfit for the trailing cars. The interchangeability of all electrical and mechanical parts of the freight and passenger electric locomotives is considered to be of very great importance from the standpoint of operation and maintenance.

The cab consists of two similar sections extending practically the full length of the locomotive. Each section is approximately 52 feet long and the cab roof is about 14 feet above the rail exclusive of the housings for ventilation. The trolley bases are about 5 feet above the roof owing to the unusual height of the trolley wire, which will be located at a maximum elevation of 25 feet above the rail. The outer end of each cab will contain a compartment for the engineer while the remainder is occupied by the electric control equipment, train heater, air brake apparatus, etc.

MOTORS

The eight motors for the complete locomotive will be type G E 253 A. This motor has a normal one-hour rating of 430 horse-power with a continuous rating of 375 horse-power. The eight motors will thus give the locomotive a one-hour rating of 3 440 horse-power and a continuous rating of 3 000 horse-power which makes it more powerful than any steam or electric locomotive ever built. The drawbar pull available for starting trains will approximate 120 000 pounds at 30 per cent coefficient of adhesion.

Each motor will be twin-geared to its driving axle in the same manner as on the Butte, Anaconda & Pacific, the Detroit River Tunnel and the Baltimore & Ohio locomotives, a pinion being mounted on each end of the armature shaft. The motor is of the commutating pole type and has openings for forced ventilation from a motor-driven blower located in the cab.

The freight locomotives are designed to haul a 2,500-ton trailing load on all gradients up to 1 per cent at a speed of approximately 16 miles per hour, and this same trainload unbroken will be carried over 1.66 and and overheating, with consequent reduction in maintenance and improvement in track conditions.

With the completion of the remaining engine divisions it is proposed to take advantage of the possibilities afforded by the introduction of the electric locomotive by combining the present four steam engine divisions into two locomotive divisions of approximately 220 miles length, changing crews however at the present division points. As the electric locomotive needs inspection only after a run of approximately 2 000 miles, requires no stops for taking on coal or water, or layover due to dumping ashes, cleaning boilers or petty round house repairs, it is expected that the greater flexibility of the locomotive so provided will result in considerable change in the method of handling trains now limited by the restrictions of the steam engine.

The electrification of the Chicago Milwaukee & St. Paul is under the direction of Mr. C. A. Goodnow, assistant to the president and in charge of construction. The field work is under the charge of Mr. R. Beeuwkes, electrical engineer for the railway company.

Handling Freight by Motor Trucks

A few years ago an innovation appeared in the way of a motor-driven truck for handling baggage in a few large railway passenger stations, and since that time great progress has been made in adapting the system to the handling of freight, with the result that the cost has been very considerably reduced. An instance illustrating the advantage gained is the report of the experience of the Central Georgia Railroad in handling cotton between the piers and storehouses at Savannah, where by the old methods of hand labor the cost was a little over six cents per bale, which the electric trucks driven by storage batteries reduced to about two and one third cents. Portable motor-driven jib crane loaders were then added, and these brought the cost, including fixed charges, maintenance and cost of power, to about 2.2 cents per bale. This is a remarkable showing in view of the fact that the electric outfit is in use only about four months each year. By the use of the loader the trucks can be loaded at the rate of a 500-pound bale every twelve seconds, which is much quicker than hand loading, and can be kept up all day, which is not the case with hand labor. Besides the money saving effected by the use of electric power there is an additional saving in time.

Arithmetical Machines—I*

Their History, Theory and Methods of Construction

By H L Goldberg, M W S. E

THE first arithmetical machine was invented as far as I know, by Blaise Pascal, about 1641 Pascal you will recall, was the wonderful Frenchman who at the age of sixteen, discovered the theorem in conic sections called Pascal's hexagram He was not only one of the foremost mathematicians of his day but also excelled in mechanics At the age of 19 he produced the first machine with mechanical means for the carrying of the tens Immediately the field of calculating machines became fertile ground and many inventors cultivated it.

The next notable production was by Leibnitz about 1671 He built several multiplying and dividing machines, and a good description of one constructed about 1700—the first in which a multiplicand could be set up and preserved during the process of multiplication—is available But this machine was never put on the market. In some of its features it resembled the Thomas machine of later years which was a well designed and well-constructed multiplying and dividing machine built by Thomas and marketed in Europe about 1820 and which is still in use

Up to that time inventors had been modest and were satisfied with making simply multiplying and dividing machines but about 1825 Charles Babbage of England became bolder and built a difference engine Let me recall to you that the series of integral values of any rational algebraic polynomial can be calculated by the method of differences This is shown in algebra It is true that many other functions for instance logarithms can be calculated by the same method of differences The method will not apply throughout the whole series of logarithms but does apply with sufficient accuracy for a group of a large number of consecutive terms Thereafter a new start is made for another group Babbage invented his machine intending originally to apply it to the calculation of logarithms as well as to the calculation of all sorts of nautical and astronomical tables When he was about half through with his first or difference machine he decided that it was not good enough, and invented what he called the analytical engine—a calculating machine that could compute any arithmetical results that could be computed by a human being. For instance it would extract square root, cube root, solve equations by Horner's process, and so on However this machine was never built. The principle on which it depended was similar to that of the Jacquard loom Many of you have doubtless seen a machine, controlled by a series of cards pierced with holes which weaves a portrait, say of George Washington Babbage proposed to juggle with numbers in the same manner as the Jacquard loom juggles with threads It was a most ambitious project, but was not fulfilled I have read his book and studied some of his mechanisms They are not as simple as they might be Babbage claims, incidentally, that to meet the necessities of his work, he was the first to graduate the screws of the slide rests of his lathes He spent a considerable sum of money advanced him by the government of England, as well as his own fortune without completing any machine

Another commercial advance we find in about 1878 when the Russian Ohdner put on the market the machine that is now called the Brunsviga and is also marketed under the names of the Marchand the Thales the Triumphator the Teitagen etc.

In this country I believe the first patent on calculating machines issued by the Patent Office was to O L Castle of Alton Ill about 1850 It was for a ten key adding machine which did not print It added in only one decimal column helping a bookkeeper to add up say the units column of a long account It could then be used for the tens and so on We find quite early key machines having a keyboard like the present Burroughs keyboard namely 81 keys Riggs in America shows such a machine about 1854 It is astounding how early some ambitious projects were launched For instance in 1871 we find that Teasdale invented a machine for multiplication Suppose it were desired to multiply 4802 by 7926 Put the multiplicand and multiplier in the machine turn the crank and presto there is your answer! No such machine has yet been put on the market although attempts have been made in that direction About 1888 the first Burroughs machine which both added and printed appeared on the market. It was quite unlike the present type which dates from about 1893 In 1888 we find the first typewriter attachment invented by Ludlum The Duplex Comptometer invented by Dorr E Felt was put on the market about eight years ago

Many patents on calculating machines have been issued by the Patent Office and under the circumstances

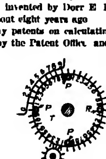


Fig 1

Fig 2

it will therefore be impossible for me to refer to any more than a few of the mechanisms described Moreover for the purpose of convenience the sketches which I have made are diagrammatic and follow no particular machine

Adding Machines —Our system of numeration is a decimal system We count in cycles of ten After reaching ten we start again to twenty then to thirty and so on Of course we have exceptions namely eleven twelve, and thirteen Logically however we should say ten one ten two, and ten three While we are able to twist ourselves and our minds into all sorts of knots mechanism refuses to be so accommodating and in a decimal mechanism eleven is always ten one and nothing else We find that almost all arithmetical machines represent the number by mechanical cycles corresponding to ten namely totalizer wheels each provided with teeth some multiple of ten for instance the wheels have ten teeth twenty teeth thirty teeth etc (Let me state here that arithmetical machines calculating with Arabic numerals have been made without the numbers being represented on wheels In fact, one machine Mr Brl ken's has no wheels whatever) In totalizers where the number is supposed to be read off by the operator it is customary to supply the wheels with the digits 0 1 2 3 4 5 6 7 8 and 9 In machines where the number on the wheels is not read by the operator the digits are not supplied For instance the Burroughs has digits on its totalizer while the Dalton has not

What means are used in putting a number into an arithmetical machine?

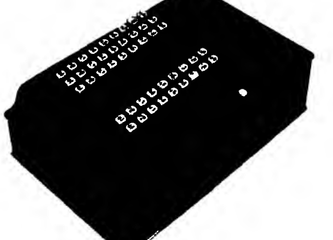
Some machines for instance the Triumph are nothing but big totalizers the totalizer wheels are so large that the operator has room enough to place his fingers through a window into the spaces between the teeth of the wheels The machine is furnished with dials indicating where the operator is to place his finger for a 1 for a 2 etc After properly locating the finger the operator pulls it down as far as it will go that is until he strikes the bottom of the window He thus rotates the engaged totalizer wheel one step two steps or any number that he desires This is certainly the most direct method and was the one used by Pascal in 1641 Certain miniature machines working on the same principle have been built but instead of using the finger a pencil or sharp stick called a stylus is placed through the window between the teeth of the wheels

Let us put the number 1[illegible] into the machine We place the finger in the 1 position of the hundreds wheel and pull down We then put the finger in the 3 place of the tens wheel and pull down And so on The capacity of the machine is of course determined by the number of totalizer wheels of which I have represented only two

Carrying Mechanism Each totalizer wheel is supplied somewhere on its circumference with a variation which mechanically determines the location of the carrying point and which arithmetically corresponds to the 0 The first step away from the 0 is 1 both mechanically and arithmetically the second step 2 and so on This variation on the totalizer wheel is ordinarily a projection like a pin as in the Wahl the Burroughs the Brunsviga and other machines On the other hand it may be instead a drop or fall or a cut as in the Howieson and other machines Of the various carrying mechanisms possible I will now explain the principle of the one illustrated in Figs 1 and 2 Something similar is used in the Wahl machine

In the totalizer there are two sets of gears the totalizer gears proper T and the intermediate wheels B Each totalizer wheel has as shown in Fig 1 forty teeth and a projection P to the left for each ten teeth The number of teeth upon the intermediate wheels is of no importance If one of the wheels T be rotated then in due time its carrying projection P will engage

Brunsviga machine



Comptometer

* A paper read before the Western Society of Engineers, and published in the Journal of the Society.

the co-operating wheel B, which will be turned, and which will thus turn one step the next higher wheel T to the left.

Let us mentally add the numbers 132 and 654. (Fig. 3, Ex. 1.) We start from the units and say 2 and 4 are 6; 3 and 5 are 8; 1 and 6 are 7. The answer is 786. In this particular example no carrying of the tens occurred. The process that did occur seems to have no universally accepted name, and I will term it accumulation. Take another example. (Fig. 3, Ex. 2.) Add 9999 and 1. Again starting from the units decimal place, we say 9 and 1 are 10, put down 0 and carry 1. We then go on, and in the tens decimal place say 9 and the carried 1 are 10; put 0 down and carry 1. In the hundreds again, 9 and the carried 1 are 10; put down 0, carry 1; and so on to the end, where we put down the last carried 1. The addition of the numbers 9999 and 1 requires practically nothing but tens-carrying. Let us take still another example. (Fig. 3, Ex. 3.) Let the two numbers to be added be 9999 and 9999. We say in the units place, 9 and 9 are 18; put down 8, carry 1; and so on. We see that in every decimal place from the units on there occur both accumulation and carrying. No new process is discovered. It will be found that addition is composed of only these two, namely, accumulation and carrying. Let us refer again to the third example. In the units place we say, 9 and 9 are 18; put down 8 and carry 1. In the tens place we say, 9 and 9 and the carried 1 are 19; put down 9 and carry 1; and so on to the end. Let me call to your attention that in this process we first accumulate, then tens-carry, then again accumulate, then again tens-carry, and so alternate one with the other to the end. That is, both the accumulation and the carrying are successive; each follows the other, and only one is done at a time.

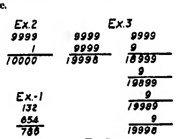


FIG. 3

On account of the limitation of the human mind, we in school are taught to add by doing one thing at a time. In addition as shown above, we accumulate and tens-carry singly and successively. The Wahl totalizer, however, is not so limited. It carries in all the decimal places simultaneously, but accumulates in only one decimal place at one time, that is, successively.

Now consider the third example from the standpoint of this totalizer. The totalizer is supposed to have already absorbed the first number, 9999, and the following description of the operation deals with the process of absorbing and digesting the second number:

First, the totalizer receives (as before described) the 9 of the thousands place. This immediately mixes with the contents already in its stomach; namely, the first number. The bite is simultaneously digested, and the result is 18999. A second bite is taken, and digested during the swallowing. The result is 19899. The 9 in the tens place is swallowed, and the result is 19989; and when the last 9 has been absorbed the result is immediately 19998. In the second example it would make one bite of the 1 in the units place, carry simultaneously throughout all its decimal places, and be completely done.

Machines whose totalizers act as just described are found among the typewriter attachments, of which the Underwood Computer as well as the Wahl are examples. The first typewriter attachment patented by Linton in 1888 operated in the same manner.

Locking Mechanism. The above is the principle of the carrying mechanism. In practice, many additional features are supplied, some of which I will point out. The quick movement of a wheel T will cause its projection P to strike the intermediate wheel B quite sharply, which thereupon will rotate the next higher wheel T, not only one step, as required, but perhaps several superfluous steps. A mistake will thus be made. To prevent such mistakes, locking mechanism is introduced. In the Wahl machine the locking mechanism is composed of Geneva gearing. This locking Geneva gearing in its turn requires unlocking mechanism, so that the final result is far more involved than the above sketch indicates. In the Underwood-Wright machine, which uses a similar carrying mechanism, overthrow is prevented by a set of spring pawls. These check the momentum of the flying wheels, but, of course, they also interpose a resistance against the free starting of the wheels, which in turn tends to motor mechanism to drive them.

You will notice that the above carrying mechanism is reversible. It will work just as well if the wheels T are rotated one way as the other. It, therefore, can be and is used for both addition and subtraction, subtraction being accomplished by rotating the gears T in the direction opposite to that for addition.

Figs. 1 and 2 show only two wheels T and only one wheel B. In practice there are totalizers with up to twenty wheels T and, therefore, nineteen wheels B. Please note that in order to function correctly, only one wheel T at a time can be used for the insertion of the number. Putting all four wheels down at once to add 9999 to 9999, would result in a mistake. This is

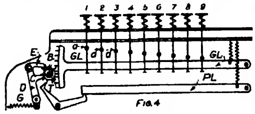


FIG. 4

because the carrying movement of the wheel B would take place at the same time as the accumulating motion of the wheel T and would thus be lost. To function correctly, all those wheels to the left of the particular wheel which is used for accumulating must be held in reserve in order to properly carry the tens. All the wheels to the right must be held non-interfering. Any carrying that does take place is, however, theoretically transmitted simultaneously throughout all the higher wheels to the left, and not successively as in the carrying mechanism to be described. The totalizer accumulates successively, but carries simultaneously.

Keys. When we come to the subject of keys, we find two distinct and contending camps. There are what are called the 81-key machines and there are the so-called 10-key machines.

The keyboard of the 81-key machine is supplied with a number of banks of keys, say nine, each containing the keys 1, 2, 3, 4, 5, 6, 7, 8, and 9. There is a bank for the units decimal place, another bank for the tens, and so on. Notice that the zeros do not occur at all. In using such a machine the operator places his finger on the proper key in the proper decimal place, and pushes. For the number 1085 he places his finger on the 1 key of the thousands bank, on no key in the hundreds bank, on the 8 key in the tens bank, and on the 5 key of the units bank. He might operate with only one finger or with all the fingers; with the fingers one at a time or all together. Operators become expert on these machines, and I have seen them use sometimes the highest figure first and units last; again, units first and the highest figure last; and sometimes a mixed order. Among the machines that have 81 keys are the Burroughs, the Comptometer, the Comptograph, the Ensign, the Wales, etc.

The 10-key machines have no sets of banks of keys, but are provided with only one set of 10 keys; namely, 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9, and this set of keys is used for *all* decimal places. Here the 0 must be used. In writing a number like 11, the 1 key is struck twice. In writing 101, the operator would strike, in order, the 1, the 0, and again the 1 key. The most prominent 10-key machines on the market are the Dalton, the Moon-

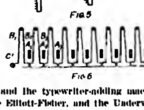


FIG. 5

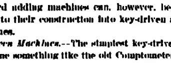


FIG. 6

Hopkins, and the typewriter-adding machines like the Wahl, the Elliott-Fisher, and the Underwood.

Keyboard adding machines can, however, be divided according to their construction into key-driven and key-set machines.

Key-driven Machines.—The simplest key-driven mechanism is one something like the old Comptometer. (You will pardon me if I do not describe the actual construction of any machine, for in that way I cannot so easily be caught in an error. Besides, in the actual machine, the mechanism occurs in several layers, which cannot be so readily understood as a diagram laying it out in one plane.)

Reference to Fig. 4 will show that there are as many banks of keys as there are decimal places. In each bank there are nine keys, to which are given the values 1, 2, 3, 4, 5, 6, 7, 8, and 9. Each key is normally kept up by a spring. Underneath them a lever GL is extended, with a gear attached thereto. Normally it is held up by a spring. There is another lever PL, which co-operates with a pawl, that can be inserted in a gear T, which is in chain with the gear upon the gear lever. When a key is pushed down, there occurs initially some lost motion; that is, the key does not strike anything. A little later a projection a on the key strikes the gear lever GL and moves it. Just when the gear lever has moved an amount corresponding to the value of the key pushed down, the bottom of the key strikes the pawl lever PL and pushes the pawl into the teeth of the gear T, thus preventing overthrow. The gear lever thus has been pushed down by a key a number of steps equal to the value of the key. Namely, the 1 key has pushed the gear lever down one gear step, the 2 key two gear steps, etc., before locking occurs. There is a ratchet mechanism (not shown) between the gear lever and the totalizer wheel T, so that on the way up the gear lever does not rotate the wheel of the totalizer.

The above is practically the mechanism of the Ludlum machine and of the old Comptometer. In the new Comptometer some modifications have been introduced. For instance, the gear lever does not rotate the totalizer wheel on the down push of the lever, but on the return thereof. Again, there are two pawl levers, instead of one, permitting the making of a portion of the mechanism twice as large and therefore stronger.

In the old Comptometer, the carrying mechanism upon the wheels T was something as follows: (Fig. 4.)

Each totalizer wheel T was supplied with a cam B, which gradually extended further and further from the center, and which was provided with a sharp drop at one point. The drop was located at the point corresponding to 0. The cam co-operated with a tooth C on a lever D. The lever had at its outer end a pawl E, which could drive a ratchet wheel on the next higher wheel T. As the lower wheel T rotated, its cam gradually pushed back the lever D, storing energy in the spring G. When the drop of the cam B passed under the tooth of the lever, the latter was no longer resisted, whereupon it flew in, and by means of its pawl E pushed the next higher wheel forward one step. This carrying mechanism is irreversible; that is, it will not work if the wheel T rotates in the opposite direction; it accumulates successively and carries successively. It was used in the Comptometer, the Dougherty, the Fisher, and the Howleson machines. In the present Comptometer a modification of this older carrying mechanism is used, which still employs the cam and sudden drop.

Full-stroke Mechanism.—Let me call your attention to the fact that in the above machine, if the operator incompletely depresses any key, he will turn the totalizer wheel an insufficient amount. He will thus register a mistake in the machine. Such is actually the case with a good many machines on the market; for instance, the Burroughs non-listing machines. To prevent such a mistake, various mechanisms called "full-stroke" have been provided. They operate about as follows: (Fig. 5.)

Let K be a key with teeth on its edge. Let B be a pawl which by means of a spring C always tends to return to its central position if displaced. Obviously, the key can now move down, but the moment its teeth engage the pawl the latter swings down, assuming a position as drawn at C', and prevents the key from rising. However, when the ratchet has moved completely past B, then the latter snaps up and the key is then free to move up again. Full-stroke mechanism is in use on the handles of many adding machines, for instance the Burroughs. It is also in use on multiplying machines such as the Brunsviga. Something similar is used as a part of the full-stroke mechanism of the keys of the Wahl.

Single-key Mechanism.—There are other troubles that are encountered in the operating of the keys. Suppose the operator inadvertently strikes two keys at once. What happens? In some machines, in fact in most machines, the result is a mistake. In others, the Wahl, for instance, it is impossible for the operator to depress two keys at once. This is prevented by what is called a single-key mechanism, constructed somewhat as follows:

Let A^1 and A^2 (Fig. 6) be the cross-sections of two key levers of a typewriter. Hanging between the key levers are some pieces B^1, B^2, B^3, whose width is equal to the distance between the centers of the key levers. On the outside of all the pieces B are two stops C^1 and C^2. The pieces B occupy all the room between the stops except the thickness of one lever A. Thus if one lever, say A^1, be depressed, it shoves B^2 and B^3, etc., to the right and B^1 to the left, and then continues without any interference. Should the attempt be made to shove two levers down simultaneously, they jointly take up too much room, and, therefore, both get jammed. The single-key mechanism is extensively used, not only on adding machines, but in cash registers and voting machines. Some of you must have wondered how it is that in the Chicago voting machines it is possible to vote for, say, only 10 out of 150 candidates. It is by an extension of the above mechanism.

(To be concluded.)

The Fluorescence of Petroleum Distillates*

By Benjamin T. Brooks and Raymond F. Bacon

FLUORESCENCE is one of the most striking characteristics of petroleum distillates, but its cause is not known, at least some of our best authorities attribute it to causes which have nothing to do with the phenomenon. The heavier distillates from Pennsylvania and certain other crude petroleums have a marked greenish fluorescence, and the trade has come to associate this property with Pennsylvania oils. For some uses it is common practice to "debloom" the oils by sun-bleaching or by the addition of certain "deblooming" substances. The subject therefore has some practical as well as theoretical interest.[1]

Engler considers that the fluorescence of mineral oils is due to their colloidal character. Crude oils and the heavier distillates are optically nonhomogeneous and show a marked Tyndall effect, but this property cannot be considered as indicating colloidal properties since many organic compounds having large molecular weights show the Tyndall effect when in true solution. Schneider and Just[2] claim to have observed ultramicroscopic particles in a "yellow mineral oil" and a sample of "paraffine oil." Holde,[3] studying the physical condition of lime soaps in grease, stated that colloidal particles are not discernible as such under the microscope. It is probable, however, from the researches of Holde that such greases, as well as oils containing asphaltic or resinous matter, are to be regarded as colloidal, not *true* solutions. Schulz[4] claimed that the effect of adding "deblooming" substances, such as nitrobenzol and nitronaphthol, was merely that of adding something having a high refractive index, thus making the oil optically homogeneous.

This theory of fluorescence of mineral oils seemed very plausible. However, since many examples of nonfluorescent oleo-resinous solutions and mixtures are known, and since the fluorescence of mineral oils persists after repeated distillation and is quite marked in distillates boiling as low as 200 deg. Cent., we believed that resinous or asphaltic matter could not be a contributing factor. Our experiments have shown that, in general, oxidizing agents partially or wholly destroyed the fluorescence. Certain facts suggested to us that sulphur or carbon in colloidal suspension might be the cause of the phenomenon. Stable colloidal suspensions of carbon in water and various organic liquids have been prepared[5] and described as nonfluorescent and brown to black in color. Sulphur, on the other hand, often shows bluish colors when in colloidal degree of dispersion, and the blue color of ultramarine blue is undoubtedly caused by so-called colloidal sulphur.[6]

We have succeeded in proving that colloidal suspensions have nothing to do with the fluorescence of mineral oils.

Working on the theory that ultramicroscopic particles were present, 100 cubic centimeters of a highly fluorescent lubricating oil were diluted with kerosene to about 500 cubic centimeters in order to decrease the viscosity. The solution was placed in a suitable cell containing two round copper plates spaced 2 centimeters apart. The oil between the plates was subjected to a unit direction field of 30,000 volts potential difference for 30 minutes without any visible change in the fluorescence or flocking out of any kind of substance.

A sample of the same solution, carefully dried by calcium chloride, was filtered through the finest filter paper and examined under an ultramicroscope of the Zsigmondy-Siedentopf type, but no particles whatever were visible. It was found that unless the oil was carefully dried and filtered particles were visible in the light cone. These may have been minute drops of water or dust. The fact that the ultraviolet light cone is made visible to the eye with bright fluorescence has no significance so far as the colloidal theory is concerned, since as a general rule the wave length of the emitted fluorescent light is always greater than the incident ray, in this case from ultraviolet to visible blue. Furthermore, the ultraviolet cone contains a certain amount of the visible rays. No more rigid proof of the non-existence of substances in colloidal suspension in carefully purified fluorescence mineral oil could be desired. In order, further, to test the arrangement and efficiency of our instrument, a colloidal gold "solution" was made by the formaldehyde reduction method, one of platinum by the Bredig method, and one of palladium by reducing with hydrogen according to Paal, and the beautiful results characteristic of this instrument were obtained.

Percolation through Fuller's earth is an excellent and well-known method for clarifying and bleaching oils. A sample of a highly fluorescent lubricating oil was allowed to run through a 5-foot tube packed with fine Fuller's earth. The resulting oil was very light in color but highly fluorescent, and when a little tarry matter, which gave brown nonfluorescent solutions in kerosene, was added to the oil until the color matched the original oil, the two could not be distinguished. The fluorescent material is therefore only slightly absorbed by Fuller's earth, and is probably not of very great molecular complexity.

While working on the colloidal suspension theory, the marked solubility of sulphur in mineral oils was noted. A 200 cubic centimeter sample of a light machine oil was heated to 100 deg. Cent. with an excess of flowers of sulphur, filtered hot, and on cooling about 0.5 gramme of sulphur crystallized out. Ubbelohde[7] states that benzine dissolves 0.5 per cent sulphur at 20 deg. Cent. It is extremely improbable that a *stable* colloidal suspension could exist in which the solubility of one phase in the other is as great as in the case of sulphur and petroleum oils.

Carbon disulphide added to a fluorescent lubricating oil weakens the fluorescence almost to the point of extinction; what remains is dark greenish. Before making the experiments with the ultramicroscope, this was thought to favor the sulphur suspension theory, or the theory of Schulz based on optical homogeneity.[8]

Further experiments with other solvents showed that the character of the fluorescence was affected by the various common solvents in the same way as in the case of the dimethylamino derivatives of terephthalic acid methyl esters, studied by Kauffmann.[9] The effect of the various solvents was even more marked with solutions of the purified fluorescent material described below. The fluorescence colors observed were as follows:

Amyl alcohol . . .	Brilliant sky-blue
Aniline . . .	Very faint green, no blue
Benzol . . .	Pure clear blue
Carbon disulphide	Faint green, no blue
Chloroform	Bluish green, passing into green on concentrating
Ether	Clear blue
Ligroin . . .	Blue
Phenol . .	Greenish blue
Pyridine . .	Bluish green

In most cases the addition of *small* amounts of solvents having high refractive indices has practically no effect on the fluorescence. The effect of adding nitro compounds therefore must have an explanation different from that offered by Schulz.

The introduction of a nitro group into the molecule of a fluorescent benzol derivative, such as the terephthalic esters, completely destroys its fluorescence. It appears that a nitro group in the solvent has the same effect as a nitro group in the molecule of the active compound itself. This is not surprising in view of the marked effect of other solvents. We believe that possibly the fluorescent substance in mineral oil owed this property chiefly to the presence of one or more amino groups as auxochromes but, as will be shown below, this cannot be the case. Although we have found that oxidizing agents destroy the fluorescence, it is probable that the action of nitro compounds is purely physical since we have added N_2O_4, nitrated kerosene or nitrobenzol to fluorescent lubricating oils chilled to 10 deg. Cent. and destroyed the fluorescence. It is highly improbable that oxidation of any hydrocarbons could take place under these conditions since at 0 deg. Cent., N_2O_4 merely adds on to ethylene bonds without oxidation.[10] There is also the possibility that such compounds as picric acid and nitrobenzol form nonfluorescent addition products, or double compounds, such as is the case with pyrene and chrysene. However, the simple nitro paraffines are not known to form such double compounds, and "nitro kerosene" is fully as efficacious as nitrobenzol for neutralizing fluorescence. The following experiment is interesting in this connection: A sample of a highly fluorescent lubricating oil was "debloomed" by the addition of nitrobenzol. This oil was then shaken out six times with one-half its volume of 90 per cent alcohol, after which treatment the blue fluorescence had reappeared and exactly matched a sample of the same oil not treated with nitrobenzol, but shaken out with alcohol in the same way as the first sample. Refining such a "debloomed" oil with sulphuric acid yields a fluorescent oil identical in this respect with that obtained by refining the original oil. The action of nitro compounds in neutralizing fluorescence must, therefore, be purely physical in character.

The fact that exposure to the atmosphere for some time partially destroys and changes the character of the fluorescence suggested that what took place during this process was slow autoxidation.

Nitrous acid readily neutralized the fluorescence of lubricating oils, but the oils gradually became dark colored and resinous. Distillation of the latter dark colored oil *in vacuo*, or with superheated steam, yielded oil having a bluish fluorescence. Repeated washing with alkali removes only a small part of the coloring matter. Shaking a part of a sample of pale engine oil with nitrous acid for 3 minutes, followed by washing with water and filtering through Fuller's earth, gave a less resinous, light colored oil, very similar to that obtained by sun-bleaching. Oxides of nitrogen, generated by the action of dilute nitric acid on a metal, were then tried, and it was found that the sun-bleached oil could be matched with respect to color and fluorescence, provided the temperature of the oil was not permitted to rise above 10 deg. Cent. before washing with dilute alkali. At low temperatures addition of oxides of nitrogen to unsaturated compounds probably results as shown by Jegorow. Unless the oil is chilled before passing in the oxides of nitrogen oxidation appears to result, accompanied by rise in temperature, darkening in color and formation of resinous material. No method of removing the resinous coloring matter without at least partially restoring the bluish fluorescence was found. The effect on the color of the oil of nitric acid in sulphuric acid, when used for refining, is well known and constitutes one of the advantages of acid made by the contact process over that made by the chamber method.

We then made a series of experiments to determine the chemical properties of the fluorescent substance. The efficiency of sulphuric acid, particularly fuming acid, in removing fluorescence is well known. It was found that the wash water from freshly prepared acid sludge tar, made by refining lubricating stock, was highly fluorescent. This suggested that the fluorescent material formed water-soluble sulphonic acids, or that the fluorescent substance was a base and removed as a soluble sulphate. The latter hypothesis can hardly be true since dilute acids do not extract the fluorescent material from the oil. A quantity of such fluorescent aqueous solution was made alkaline and extracted with ether, but no fluorescent material was obtained, indicating that the substance in question is not a base. A dilute acid solution of the fluorescent substance was nearly neutralized with lime to remove the excess of sulphuric acid. The filtered aqueous solution was evaporated nearly to dryness and the crystalline residue, containing sulphate of lime, extracted with alcohol. Twelve liters of lubricating distillate yielded in this way about 1 gramme of an impure crystalline residue which was intensely fluorescent when dissolved in the different solvents named above. The amount obtained was too small to be thoroughly investigated, but we hope that we shall have an opportunity in the near future to prepare a quantity of this highly interesting material sufficient for further work. The above results were enough to show the general character of the substance. The crude fluorescent substance probably contains one or more compounds of the benzine series resembling, or perhaps identical with, chrysene, fluorene or pyrene. Such compounds are known to be formed by the pyrogenic decomposition of many organic substances. Klaudy and Fink, in 1900, isolated a yellow crystalline substance, giving highly fluorescent solutions, from the residuum of a cracking still. They gave it the formula $C^{24}H^{18}$.

A large proportion of the fluorescent substance or substances is formed during the distillation of the crude. This was shown by distilling a sample of Oklahoma crude at atmospheric pressure and under a pressure of 5 millimeter of mercury. The distillates in the first series were very much more fluorescent than the latter. This is also true of the distillates from coal when distilled at atmospheric pressure and under a pressure of 5 millimeters. Parallel with this difference it should be noted that substances of the benzol series form a much greater proportion of the coal tar obtained at ordinary pressures, paraffines and olefines constituting over 80 per cent of the coal tar obtained by distilling *in vacuo*. It is also well known that no fluorescent substances are known belonging to the paraffine series.

Halogenation destroys the fluorescence, as is to be expected. Hydrogenation also destroys it.

* Presented at the 49th Meeting of the American Chemical Society, Cincinnati.

[1] Cf. "Relations between Physical Properties and Constitution," Kayser, "Handbuch d. Spectroscopie," Vol. IV., p. 831. Kauffmann, "Beziehungen zw. Fluorescenz u. Chem. Konstitution," *Samml. Chem. u. Chem.-tech. Vorträge*, 11, 1906.

[2] *Z. f. wissensch. Mikroscopie*, 1905, p. 480.

[3] *Z. f. angew. Chem.*, 21 (1908), 2138; *Koll. Ztschr.*, 3 (1908), 270.

[4] *Petrol. Berl.*, 5, 205.

[5] Thomae, *Koll. Ztschr.*, 11 (1912), 268; Vanzetti, *Koll. Ztschr.*, 12, (1913), 6.

[6] Liesegang, *Koll. Ztschr.*, 7 (1910), 307; Hoffmann, *Chem. Ztg.*, 1910, p. 1,072.

[7] *Petroleum*, 1913, p. 1,309.

[8] The refractive index of carbon bisulfide is N_D-20°—1.6276.

[9] *Ann. d. Chem.* (Liebig—, 393 (1912), 1.

[10] Jegorow, *J. prakt. Chem.*, 86 (1912), 512.

Cement from Beets

IT is now reported that a French firm is making an excellent cement from a by-product in the process of making beet sugar. The scum that forms when the beets are boiled, and which has heretofore been thrown away, consists largely of carbonate of lime and water, and from 70,000 tons of beets treated 4,000 tons of carbonate lime is obtained; to this 1,100 tons of clay is added, the resulting product being 3,162 tons of excellent cement. The scum is pumped into large tanks, where it is allowed to dry partially; finely divided clay is then mixed with it; the mixture is thoroughly amalgamated by beaters for an hour and burned in a rotary kiln, much in the same way as Portland cement. The clinker is then removed and pulverized into cement.

"Suction" Between Passing Ships—III*

Important But Little Understood Forces Affecting the Motion of Vessels

By Sidney A Reeve, M E

Concluded from Scientific American Supplement No 2037, Page 48, January 16, 1915

IV ACTUAL INSTANCES OF "SUCTION" COLLISION

The following descriptions are condensed from the records of the American Admiralty courts Usually the quotations are from the decision handed down by the court summing up and balancing the conflicting testimony Wherever possible charts of the date of the collision have been consulted

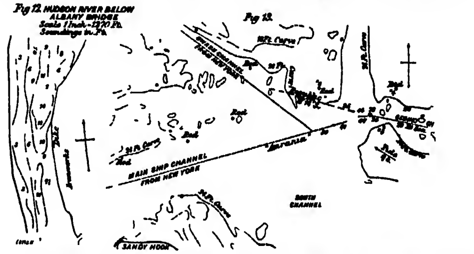
Case 6 Andus Saratoga September 21 1877 Hudson River near Albany (Fig 12) A southbound tow consisting of eleven barges banked three abreast was moving parallel with the dike (really a wharf the true dike being on the opposite side of the river) The steamer Saratoga 300 feet by 66 feet also south bound undertook to pass between the tow and the wharf When the bow of the S had overlapped the aftermost barge some 40 feet the tow sagged down with the wind (which was westerly but very light) against the S The court held that the wind theory was not upheld by the facts and hence disbelieved that the sagging occurred at all The term suction was not mentioned but in the light of later knowledge it is a clear case The courses are such that a shoaling of the water from 14 feet to 9 feet occurs just where the wharf also converges on the courses The vessels probably had a draught of about 6 feet and their aggregate beam amounted to nearly the width of the channel Under such conditions suction was inevitable. But its hydraulic theory in this case falls more under that of canal-waves than of two-dimension stream-lines which former the student will find discussed in the references listed in the first article of this series page 31 ante

Case 14 Aurania Republic September 19 1885 3 24 P M 2 miles northeast by east of Sandy Hook (Fig 13) This is the first recorded suction collision between first-class liners In fine weather with sea smooth tide flood and wind light the A (480 feet by 56 feet by 26 5 feet draught 14 7 knots) and the R (420 feet by 42 feet by 25 2 feet draught 13 2 to 13 5 knots) collided as they were about to enter Gedney Channel the stem of the R striking the port quarter of the A when the latter's stem was about 100 feet west of the buoy (double circle in Fig 13) The A had come down the (old) Main Ship Channel and the R down Swash Channel Each vessel headed for the buoy There is the usual conflict of testimony as to locations and courses but the agreement is closer than usual The court concluded that the ships were on courses converging by 1½ points as drawn But this conclusion disregarded the R's claim as to angles and distances because at a distance of 500 feet to 700 feet apart one minute before the collision no possible suction port helm or other influences from the A could have had any sensible effect upon the R at that distance or have sensibly neutralized or delayed the effect of the hard a starboard helm which her officers say the R was then under and in spite of which as they say the vessels came together But had the court been equipped with an adequate theory of suction the decision would probably have been reversed The court was misled by the idea that suction is a force drawing the two hulls bodily together whereas it is almost wholly a sheering or swinging pair of forces one attracting the bow and the other repelling the stern It is the forward momentum of the pivoted vessel and not the attraction of suction which brings her into the other ship Thus in this case the R was traveling at about 1 350 feet per minute According to the court's theory the point of collision was only some 170 feet to starboard of the R's course At her rate the suction-sheer need have been through an angle of only two points beginning one-quarter minute before the impact to have cleared the space between the two vessels and at its inception the ships would have been only 400 feet or 500 feet apart

Most of the witnesses on both sides seem to agree that shortly before the collision the stem of the R seemed to be approaching the A's quarter more suddenly and rapidly than their previous angle of convergence would account for The evidence leaves no doubt that the R's engines were stopped and reversed just prior to the collision The court knowing that the R carried a hard a-starboard helm and finding no other explanation, attributes the sheer to the 4-mile breeze! Navigation would be hazardous indeed if a 4-mile breeze could entail such a disaster

Fig 13 (from a chart of 1884) shows that the water was shoaling rapidly beneath the A at the rate of 15 feet in a ship's length at the time and place of collision This coupled with the convergence of courses at an angle variously stated as from 16 degrees to 38 degrees was undoubtedly the cause of the overwhelming suction Although an unknown depth of tide must be added to the soundings of the diagram the ships were drawing most of the water to be had beneath the A's stem Had they met a minute later over a flat sea-bottom, they would probably have escaped disaster This same locality became the scene of another suction collision (case 35) between sea-going liners but at a later date when dredging had deepened the shoal spots

Case 17 Hartt - "City of Brockton, September 29, 1887 outside Sandy Hook The B (paddle-steamer 283 feet long) overtook the tug H (125 feet long) as both were going to an international yacht race When Sandy Hook was passed and South Channel reached (see Fig 13) at about the time when the paddle-box of the B was abreast of the pilot-house of the H the latter gave a sudden lurch towards the B which shortened the distance between the two about one-third The H then straightened up Then she lurched again toward the B and instantly the collision occurred the bow of the H striking first the port paddle-box of the B and then running under the B's port guard where



she was near being capsized most of her passengers being thrown into the sea The movement of the H is described by Mr A as a lurch It wasn't a case of gradual converging Another calls it a grand swoop right around Another says she made a dive for us The court attributed the action to the powerful action of the B's wheels but hydraulic theory finds complete explanation in the interaction of the H's constrained wave with the B's echelon waves The latter are independent of the ship's model their length depending only upon the speed The B's speed is stated as 14 to 15 miles At 14 knots its echelon wave would be 109 feet from crest to crest and at 15 knots 125 feet It is plain that the H's constrained wave must have had a length suitable for interaction with the B's echelon As one echelon crest came into phase the H took its first lurch As the next crest came into phase the second lurch occurred It is not likely that the sea-bottom was a contributing cause though there are banks about 20 feet deep in this vicinity which may have helped

Case 18 'Switzerland - La Gascogne,' January 21, 1888, New York Upper Bay, both vessels bound to sea water 60 feet to 75 feet deep In clear daylight with no other vessels interfering, the L G (480 feet by 52 3 feet 7,415 tons gross 15 to 16 knots) having come up with the S (329 feet by 38 8 feet, 2,601 tons, 9 to 10 knots), was passing her on the port side at a distance estimated by various witnesses at 150 feet to 300 feet The bow of L G had drawn ahead of the bow of the S when the vessels came into collision, the S's bow striking L G on her starboard quarter at an angle of about 30 degrees The lower court held the S at fault, but the upper court reversed this Both courts, in order to develop a consistent explanation in lack of true hydraulic theory, were forced to disregard some well-founded evidence But with suction properly in mind no violence to the facts is needed The L G had to port somewhat at this point in the channel, and a very slight convergence of the two courses, if not noticed immediately by the S, would bring the latter into control of suction very quickly Collision might occur from this cause within 45 seconds from an original distance of 250 feet or in 26 seconds from 150 feet, if the L G's porting had been only one point

Case 20 ' Devereaux"-"Folsom' -"Mitchell," August 13, 1890 This was the first case in which the court considered suction as a cause when the vessels were passing in opposite directions It occurred in a dredged channel between Lakes Huron and Michigan, about 300 feet wide by 25 feet deep The D (270 feet by 37 feet) passed at 4 knots the tug F (185 feet by 35 feet), and sheered enough, uncontrollably, as she did so to collide with the schooner M in tow of the F The tendency of every ship to ' smell a bank and sheer away from it was mentioned in the decision, and it is certain that this tendency would be exaggerated at the moment the F passed

Case 21 ' City of Macon '-' Nedjed," December, 1890 Savannah River a variation of the preceding case When the M (about 300 feet long) was partly lapping the N (320 feet by 45 feet by 19½ feet draught) about 100 feet away in a channel 400 feet to 450 feet wide by 20½ feet deep, the N sheered across the M's bows, away from the wharves, and ran in the mud-bank opposite

Case 24 Mather - Ohio - Siberia " In daylight date not stated Mud Lake St Mary's River, Great Lakes Mud Lake is virtually open water, being 3 miles wide by 25 feet to 30 feet deep for 100 feet to 300 feet on either side of the course The M (260 feet by 15 feet draught) had overtaken the S (274 feet by 15 feet draught) about 40 feet to 75 feet away on the latter's starboard hand The O was meeting the S port to port When the M was about a half-length in advance of the S the latter sheered suddenly to port, and within less than 60 seconds struck the O,' and sank her ' The evidence seems to leave no reasonable doubt that when the effect of suction began to be noticeable these boats were within 40 feet to 75 feet of each other, and that the stern of the M was about abreast of the foregigging of the S At this point it is in evidence from both sides that the speed of the S seemed to be increased, and that she ran up on the M some 10 feet or 15 feet Yet it is uncontradicted that the steam of the S was not increased This temporary increase of speed by the slower boat is shown to be one of the effects of suction It has been argued that, if suction had exerted any force upon the navigation of the S, it would have shown its effect by attracting or drawing her closer to the vessel within whose influence she was, and not as a repulsing force throwing her off to port But evidence of just such an attractive force appears " Evidence is then quoted by the court tending to show that the S was first drawn in towards the M, and then, later, whether assisted by a starboard helm or not is not known, sheered off toward the O The facts emphasize the instability of steerage under such conditions. Perhaps a hard-a-starboard helm was assumed when the first sign of suction appeared, and thus, after steadying her against the suction, carried her too far to port for her to recover within the 30 seconds available before she met the O. Or the lack of testimony as to the helm of the S might suggest a jammed helm. In any event suction was plainly the original cause of the disaster.

Case 25: "Aurania"-"Wilhelmina," January 15,

* Reproduced from *Engineering*

1898, 2 P. M.; Delaware River, about 1 mile down Deep-Water Point range, with apparently ample room laterally, but very little depth. The bottom is even, but the charted depths are everywhere less than the draught of either ship; tidal depth not known. The A (345 feet by 46 feet by 23 5-26 feet draught) overtook the W (325 feet by 41 feet by 22 5-24 5 feet draught) on the latter's port hand, passing at distances variously stated as from 75 feet to 300 feet, the court favoring the smaller distance, as from more reliable witnesses. "Before the A's bow was opposite the W's bridge the W's pilot ordered the wheelsman to port the helm because he saw the A was coming too close. When the A's bows got abreast of the W's bridge, he says he told the captain to slow the ship to half-speed and that when her stern got somewhere about half way between the W's fore-rigging and the bridge he had the engine stopped; that he then asked if the wheel was a-port and that the chief officer replied that it was hard-a-port; that he then went and looked himself and found that it was so; and that the A was at that time about 75 feet to 100 feet away." When the A's stern came forward of the W's bridge the W took a sheer and struck the A a glancing blow upon the starboard quarter about 35 feet from the stern. "This sheer of the W the pilot accounts for by what he calls suction." Both vessels had to return to Philadelphia.

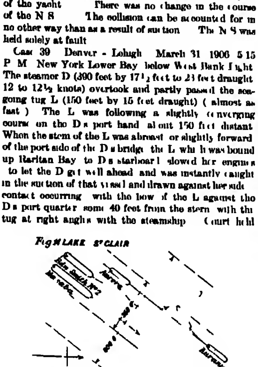
The court referred to the cases of the Folsom, the "Cleveland, the Umit, the Marcel and the Brockton." "The cases above referred to judicially recognizing the existence of the force called suction and its power under favoring circumstances to draw one vessel towards another, cannot be disregarded by this court."

Case 26. Mesaba - Smith - Aurania. "On a bright July day in 1898 in the dredged channel in Lake St. Clair above Detroit. In 1898 the St. Clair Channel was 350 feet to 400 feet wide by 20 feet deep, the Detroit channel 800 feet wide, and of equal depth. As it is not stated just where the collision occurred, both widths are given in Fig. 14, which is drawn to scale as to the lengths of the ships and tow line, but not as to lateral distances, which are unknown. The case is cited as an interesting one of three-ship action which is plainer from the diagram than from the description. The S was apparently not affected by the M until the Aurora was met, although the first two had been traveling at not widely differing speeds. The S recovered from her first sheer, apparently caused by her bow entering the Aurora's lateral depression, but took a second and uncontrollable sheer just after passing the Aurora. "The 'Aurania's' helm was hard-ported and the Aurora's engine stopped and the lever controlling the towing-machine on the Aurora released so that the cable might reel out; there being no time or opportunity to let go the line on either vessel; but so extreme and rapid was the sheer of the S that she struck the tow-line at nearly a right angle about 100 feet ahead of the 'Aurania,' parted the wire cable and then swung around the bow of the 'Aurania' which struck the S on the starboard quarter. The vessels came together with great force driving the bow of the A to port and straightening the S up in the channel, so damaged that she filled and sank after going a short distance while the A with bows badly stoved forged ahead and drifted diagonally down and across the channel until she brought up on the bottom, aided in this by a stern anchor which she had let go."

Case 35. "Martello - Mesaba, September 22, 1900, 10.42 A. M., New York Lower Bay, entrance to Gedney Channel, Fig. 13, but by this date dredging had reduced the slope of the bank to about 10 feet in a ship's length. Nor is the place of collision so exactly located as in the case of the 'Aurania'-'Republic.' An ebb-tide of 1 knot was with the ships. Both ships went down the old Main Ship Channel. They passed Sandy Hook with the "Martello" (370 feet by 43 feet by 28 feet draught, 10 knots) said to be one-third mile ahead of the Mesaba' (482 feet by 52 feet by 29¼ feet draught, 13 knots) but if this gap was closed by the time they reached Gedney there could have been a difference of only about 3 knots in their speeds. While the 'Mesaba' was passing the 'Martello' on the northern side, 'probably from 100 feet to 150 feet' distant, when the Martello's stem was about abeam of the Mesaba's amidships or a little more aft, the 'Martello's' bow was seen to turn to port toward the 'Mesaba,' and it continued to turn more rapidly as the 'Mesaba,' advanced, until the bluff of her port bow, about 20 feet from her stem struck the starboard quarter of the 'Mesaba,' about 100 feet forward of her stern, a violent blow. The 'Martello' was obliged to return to New York, while the 'Mesaba' continued her voyage." The court held that suction was the cause of the collision.

Case 37: "North Star"-"Nourmahal," September 28, 1901, 4 P. M. Swash Channel, New York Lower Bay (Fig. 13, just beyond the northern edge of which, where the eastern bank of Swash Channel is steeper, the collision occurred). The yacht N (247 feet by 30 feet by 19 feet to 16 feet draught, 15 knots) was overtaken on her starboard hand by the N S (320 feet by 46 feet by 13 feet to 15 feet draught, 17 knots). When the yacht was about 600 feet ahead of the N S they were apparently something more than 100 feet apart but were drawing slightly nearer and when the N S's stern reached a point about opposite the bridge of the yacht the latter being influenced by the N S's suction turned towards her and the vessels came together notwithstanding a starboard then hard a-port helm on the part of the yacht. There was no change in the course of the N S. The collision can be accounted for in no other way than as a result of suction. The N S was held solely at fault.

Case 39. Denver - Lehigh. March 31, 1906, 5.15 P. M. New York Lower Bay below West Bank Light. The steamer D (390 feet by 17½ feet to 23 feet draught, 12 to 12½ knots) overtook and partly passed the seagoing tug L (150 feet by 15 feet draught) (almost as fast). The L was following a slightly converging course on the D's port hand about 150 feet distant. When the stem of the L was abreast or slightly forward of the port side of the D's bridge the L which was bound up Raritan Bay to D's starboard slowed her engines to let the D get well ahead and was instantly caught in the suction of that vessel and drawn against her side, contact occurring with the bow of the L against the D's port quarter some 40 feet from the stern with the tug at right angles with the steamship. Court held



the L at fault for slowing whereby she surrendered a certain amount of power and became less manageable. Damages were divided. The water was 28 feet to 31 feet deep with no marked lumps in the bottom.

Case 41. Saratoga - Taunton. June 17, 1907. Delaware River, Horseshoe Bend (Fig. 15). This is an interesting case of bank-sheer. The S (430 feet by 50 feet by 18 feet draught) coming down the river at 8 knots with a helping tide of 2 to 2½ knots struck and slipped off the seventeen foot lump at buoy C 17, sheered suddenly about 4 points across the channel and collided with the T.

Case 43. Parima - Prinzessin Irene. April 4, 1908. New York Lower Bay, 700 feet to 1,000 feet north of the buoy on point of the shoal between Main Ship and Swash Channels and 1,700 feet to 1,800 feet west of the red bell-buoy. No court decision was ever rendered on the facts of this case, the following outline being the result of the author's attendance at the trial. The P (335 feet by 42 feet by 21.3 feet to 21 feet draught) was going down Main Ship Channel at 10¼ knots when she was overtaken on her starboard hand by the P I (524 feet by 60 feet by 22.6 feet to 24.8 feet draught) at an estimated speed of 13.8 knots. The ebb tide increased these speeds about one knot and altered their apparent course 4 degrees or 5 degrees eastward. When the bow of the P I was abreast of the P's mid-length and from 150 feet to 250 feet distant the P sheered to port, ran over the perch-and-square buoy, and ran aground. The P libeled the P I as being the overtaking vessel and the cause of her going aground.

The case is, in the writer's belief, a plain case of repulsion of the leading ship during the first phase of passing. The water, which shows a general depth of 31 feet to 32 feet (plus 2 feet of tide), is amply restricted to account for the sheer, which took place against a hard-a-port helm. In addition, the 1:40,000 chart of New York Harbor shows a single sounding of 22 feet at or just north of the place of sheer, but a chart of 1:5000 which appeared in court did not fully corroborate this lump. But even without it a sheer on the part of the smaller ship passed at such speed and propinquity by a vessel of over three times her tonnage drawing most of the water in the channel would be only natural. This case is of further interest in that the officers of the P I were not aware until they reached Germany that their ship had been regarded as connected with the accident in any way.

Case 44. Monterey - United States. April 16, 1908, 1.30 P. M. New York Lower Bay, Main Ship Channel just above the entrance to Swash Channel, in almost the identical spot of Case 43, except further toward the westward side of the channel. Weather clear, wind light, tide last of ebb netting 0.8 feet below the mean low water of the chart soundings. The twin-screw steamship M (341 feet by 47½ feet by 20 feet draught, 12 knots) was overtaken about abreast of the bell buoy and well over to the westerly edge of the channel by the U S (501 feet by 58 feet by 27½ feet draught, 15 knots) which was converging on the M's course by a half point. The clearance was stated as anything from 75 feet to 800 feet (the entire width of the channel being 1,100 feet) the court favoring 100 feet. As the U S drew up abreast the helm of the M was kept steady a-port, a caution to the wheelsman to keep her perfectly straight and counteract any tendency of the vessels to veer together. When the U S was from one-third to one-half past and the bow of the M was opposite a point about two points abaft the beam of the U S the M turned in the direction of the U S notwithstanding a hard a-port helm and the starboard engine being put full-steam astern and the port engine being kept going ahead to assist the port-helm. Upon its being found that these precautions did not have the desired effect both engines were reversed at full speed but the collision occurred, the bow of the M striking the starboard side of the U S at an angle of about two points. There were two blows on succeeding the other almost immediately. The U S was damaged to such an extent that it was necessary to beach her. The M was also seriously damaged but she remained afloat.

The lump in the bottom of this channel mentioned in connection with Case 43 apparently extends entirely across the channel. The depth at the black spar buoy opposite the red bell buoy was 26.2 feet that day. Considering that the M which must have been close to this buoy was drawing 20 feet while the U S drew over 27 feet, the slightest lump in the bottom would suffice in addition to the half point of convergence to develop a suction sheer. The lateral proximity of the bank on the M's starboard hand would also contribute a strong tendency to sheer to port towards the U S.

It is also to be noted that whereas in many cases of suction the sheer occurs in spite of hard-over helm, in this case it defied the controlling power of twin screws as well. In the Chicago - Oswego case (not reported here) the latter vessel when she sheered dragged one tug sideways through the water broadside and overcame the direct engine power of another working in conjunction with partial power from her own engines. Such facts as these show how uncontrollable is the force of suction when once initiated.

Case 45. Murcia - Sif. November 26, 1908, 2 P. M. Delaware River, Cherry Island, about opposite Wilmington, Del. (Fig. 16), weather clear and calm, flood tide. In the cut, which is about 700 feet wide by 33 feet deep by chart, or 29 feet by testimony, the M (303 feet by 41 feet by 21 feet draught) was overtaken on her port side by the S (325 feet by 47 feet by 21 feet draught). Speeds are not stated; clearance stated contradictorily, but according to the S 300 feet to 400 feet. According to testimony on behalf of the initial clearance when they began to overlap was 100 feet to 150 feet, but that as the S gradually drew ahead of the M the former converged slightly upon the course of the M so that when the S was about half way by the M the distance between them had been reduced to from 50 feet to 100 feet when the engines were slowed then stopped and finally put full speed astern and the helm a-port. Notwithstanding this maneuver the M continued to approach the S more rapidly and then gave a sudden dive in the direction of the latter, the bluff of the M's port bow striking the S on the starboard side at a point about 100 feet forward of the latter's stern. Both vessels were injured.

The court quoted the opinion of Judge Gray in Case 25. In this present case however in contrast with Case 39 the pilot of the overtaken vessel was commended for slowing his engines. In this case too as in several others the court leant toward the smaller of the variously stated clearances on the ground that the time available would not permit the sheering vessel to cross a wider intervening space. But as nearly all these decisions have been rendered without any more accurate idea of suction than as a bodily attraction between the

two hulls the rapidity with which a ship in motion can cross lateral space by being rotated rapidly while she moves ahead—which is what suction does as well as accelerate the forward motion at the same time—has not been appreciated by the court This line of reasoning annuls the court's conclusions as to the probable actual clearance and makes it probable that many of these suction sheers occurred under initial clearances much greater than those stated in the court decisions

Case 47 Kennebec Strathnairn January 26 1910 8 A M Patapsco River Baltimore Harbor weather clear wind light, tide early ebb The S (380 feet by 52 feet by 24 feet draught 2 811 tons 5 or 6 knots) came down the Sparrows Point Channel (100 foot wide by 25 feet deep) and made the almost square turn of 70 degrees into the Brewerton Channel (600 feet wide by 30 feet deep) There she met on her starboard hand the K (250 feet long 1 940 tons 7 to 9 knots) also going down Brewerton Channel When the ships met their courses were parallel or slightly converging the S being from 250 feet to 300 feet ahead so that the K overlapped by 75 feet to 100 feet lateral distance not stated The vessels came together in the usual suction manner but without room for as much angular rotation as usual nor were the speeds high Consequently the K struck the S with the side of her bow and while each vessel was damaged neither was disabled

NEW BOOKS, ETC

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HOW TO MAKE A LOW PRESSURE TRANSFORMER By Prof F E Austin Head of the Department of Electrical Engineering at Norwich University New Hampshire 14 pp Price 25 cents

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LE HASARD By Emile Borel Paris Librairie Félix Alcan Price 3 francs 50 centimes

A thorough discussion of chance is possible only in a work of a mathematical character so profound that it would be hopelessly beyond the ordinary reader But it is possible to give some idea of the methods which are employed by the mathematician in determining the probability of a certain thing's happening or not and also to show how important it is to apply the doctrine of chances to science and to human affairs Prof Borel has performed this task extremely well His book is divided primarily into three parts The first is an exposition without superfluous formulæ of the principles of the doctrine of chance such cases as fall within the theory of limited and unlimited alternatives and of inverse probability being taken up The second part is devoted to the applications of the laws of chance to various sciences such as sociology physics astronomy biology and chemistry The third part is of a philosophical character and gives the reader an idea of the manner in which chance plays its part in human affairs

HISTORIC HOMES OF NEW ENGLAND By Mary H Northend Author of Colonial Homes and Their Furnishings With numerous illustrations Boston Little Brown & Co 1914

For many years Miss Northend's name has been familiar to the readers of monthly magazines devoted to the home as a writer on New England life A resident of Salem and a member of a family well known in New England she has brought to her work the sympathetic understanding which is to be expected of one whose character has been molded by the traditions of New England In her present work she takes us by the hand as it were into the old mansions which have made New England architecturally famous—the House of the Seven Gables the Pickering house the Rogers house the Adams house the Governor Dummer mansion and others Her descriptions of these wonderful old dwellings and her beautiful photographs of their exteriors and interiors should prove inspiring to our architects and to those who have a love for the best in our Colonial architecture

DYNAMIC EVOLUTION A Study of the Causes of Evolution and Degeneracy By Casper L Redfield New York G P Putnam's Sons 1914 12mo 210 pp Price $1 50 net

Dynamic Evolution puts forward a theory of animal energy and postulates rules governing its transmission It increased or diminished quantity A close examination of pedigrees in stock is used as the foundation of the argument which proceeds logically toward its application to man and mentality The conclusion drawn is that transmitted energy whether physical or mental increases up to an advanced point with the age of the father In support of this theory the author advances the fact that in the case of ten of the world's greatest men the average age of the fathers at the time of the sons births is found to be no less than 55 years The ten notables are Aristotl Augustus Bacon Buddha Confucius Cuvier Franklin Humboldt Ptolemy II and Solomon Sons of young fathers are declared to be inclined toward militarism and aggressiveness sons of more mature sires to the fine arts and statesmanship while the old fathers convey moral and philosophical bias

ELECTRIC COOKING HEATING AND CLEANING A Manual of Electricity in the Service of the Home By Maud Lancaster Edited by E W Lancaster A M Inst C E American Edition revised by Stephen L Coles formerly Managing Editor *Electrical Review* New York D VanNostrand Company 1914 8vo 329 pp 305 illustrations Price $1 50 net

In England there are a score of districts where electricity for household purposes is obtainable at a cost of one cent per unit As the American charges vary from 3 to 20 cents per unit the advantage our English cousins possess—an advantage of which they have largely availed themselves—may be readily appreciated Even under the handicap of high cost however the essential cleanliness and convenience of this service is daily widening its appeal The attractive volume in hand written by a woman especially for women shows all the modern devices for cooking heating and cleaning electrically and describes their practical operation The enthusiasm of the author is contagious her points well made and not to be overlooked is her strict attention to economy The work is carefully adapted to the requirements of the American reader and no small proportion of the apparatus it illustrates is of our own manufacture

THE GAS TURBINE By Norman Davey New York D VanNostrand Company 1914 8vo 248 pp illustrated Price $4

Of the two existing works in English on the gas turbine the early monograph by Suplee is now inadequate says Norman Davey because it has nothing to say about the Holzwarth turbine while Herr Holzwarth's book is inadequate because it has nothing to say of anything else Mr Davey gives us a comprehensive view both of theory and practice and his contribution is opportune and welcome Of the three types of gas turbine the constant pressure mixed fluid has been hitherto slighted Considerable attention is here given to that type A study of the variation in thermodynamic constants and its effect upon efficiency concludes the theoretical division of the volume The discussion of practice includes the accessory machinery and practical limitations summarizes efficiencies and compares types and regards the gas turbine in the light of history of experimental progress and of future possibilities A list of turbine patents from 1856 to 1913 is appended

THE MISSISSIPPIAN BRACHIOPODA OF THE MISSISSIPPI VALLEY BASIN By Stuart Weller Illinois State Geological Survey University of Illinois Urbana 1914 4to text 508 pp , 83 plates separately bound

The fossil yield of the Mississippian formations is exceedingly rich and the present monograph is only a beginning toward a compact and accessible literature of their forms All the known brachiopods of the region are described in this report known as Monograph I It discusses each species and records the geological formation of which the species is a member The volume of plates invariably mentions the exact locality of the specimen illustrated

STEEL CONSTRUCTION A Text and Reference Book Covering the Design of Steel Framework for Buildings By Henry Jackson Burt C E Chicago American Technical Society 1914 12mo 383 pp illustrated

In a handy attractively bound little volume a well known and thoroughly competent structural engineer sets forth facts and formulas governing the erection of steel framework for buildings Basic principles are lucidly explained The practical illustrations accompanying the formulas conduce to independent thought on the part of the student and at the same time demonstrate current practice A sixteen-story fireproof hotel is presented in a complete set of drawings with all necessary explanations and details

CARD READING By Minetta With Introduction by Sepharial Philadelphia David McKay 12mo 104 pp , illustrated Price 50 cents

The more impressionable sex may derive a dubious sort of pleasure from the dictum of the cards upon such vital questions as Who is near to me? Who is dear to me? —though one would think the answers to these scarcely required a resort to occult aid The introduction seeks to place cartomancy upon a scientific basis The result can by no stretch of courtesy be called convincing to the average intelligence

ALCHEMY ANCIENT AND MODERN By H Stanley Redgrove B Sc (Lond) F C S Philadelphia David McKay 8vo 141 pp 16 full page illustrations Price $1 50 net

The old alchemy whether regarded as a philosophy or a chemistry is not devoid of interest In its better-known, chemical aspect it inspired research formulated laws and evolved into practical pursuits Admitting this Alchemy Ancient and Modern by devoting nearly a hundred of its one hundred and forty-one pages to the charlatans and charlatanry of a dead day must be regarded rather as an historical study of curious human traits than a monograph on radio-activity which is lightly disposed of in one short chapter For this reason the work will commend itself to him who dreams in the past rather than to him who lives in the present

PSYCHO-THERAPY Its Doctrine and Practice By Elizabeth Severn Ph D Philadelphia David McKay 8vo 211 pp Price $1 25 net

It is seldom that we have a book of this nature from a pen of such broad culture and practical philosophy If the author claims too much for her method toward her personal attainments she exhibits an admirable modesty and restraint Her knowledge of human nature is so true that involuntary chuckles escape the reader from time to time She represents the best side of mental treatment shorn of all the isms that so frequently turn it to disaster She does not seek to establish psycho-therapy upon a religious basis Several chapters of the work may be read solely for the instructive glimpses they afford us of our frailties and the inner strength that may be summoned to overcome them A novelist would find these a mine of character in which the author's own character is the richest nugget Withal her arguments are so circumstantially marshaled that we occasionally find ourselves convinced against our will

AIR WATER AND FOOD From a Sanitary Standpoint By Alpheus G Woodman and John F Norton of the Massachusetts Institute of Technology New York John Wiley & Sons, Inc 1914 8vo 248 pp illustrated Price $2 net

The three previous editions of this textbook have been favorably received and as the present edition embodies the various advances that have been made in analytical methods it should meet with a like kindly reception Originally written from the missionary standpoint it has come into somewhat wide use as a text for colleges and technical schools In it the three great essentials of our human existence are discussed in their relationship to health Known facts are interpreted in an unprejudiced manner and analytical methods take up much of the allotted space Upon all the subjects dealt with a wider and surer knowledge is a crying necessity and the work is deserving of a growing circle of readers that shall pass on its teachings to the lasting benefit of their communities

BILL'S SCHOOL AND MINE A Collection of Essays on Education By William Suddards Franklin South Bethlehem Pennsylvania Franklin MacNutt & Charles 1913 12mo 98 pp Price 50 cents

Bill's School and Mine is in the large a contrasts between the free boy life of the open country and the restricted environment of encroaching civilization Other papers follow, on The Study of Science and Part of an Education all exhibiting a breadth of culture and a keen outlook on the part of the writer that is as rare as it is energizing He not only has a distinctive way of saying things but he has distinctive things to say His remarks on the study of physical science are so embracing as to the various phases and difficulties of the question that we can but wish all parents teachers and students might read and profit by them

THE ART COMMISSION OF THE CITY OF NEW YORK Report for the year 1913 8vo 32 pp illustrated

Aside from a list of the members and of committees appointments this Report mainly concerns itself with the various public structures and works of art passed upon by the Committee during the year It is enlivened by both approved and disapproved designs as in the cases of the Straus and Bowne memorials and the fire house plans There are plates of old New York buildings of historic and architectural interest A general sketch of the year's activities forms the subject-matter of the main section The scope of the Commission is detailed and there are illuminating paragraphs upon what constitutes true art in certain special structures and sculpture. The Report should be of interest for all who have the beautification of the city at heart.

THE SPECTROSCOPY OF THE EXTREME ULTRA-VIOLET. By Theodore Lyman, Ph.D New York Longmans, Green & Co , 1914. 8vo , 135 pp.; with diagrams. Price $1.50 net

Since the absorption of air is slightly apparent in the ordinary ultra-violet the smaller portion of this monograph deals with that region of the spectrum which lies between wave-lengths 4,000 and 2 000 This is introductory to the real discussion which is a study of the Schumann or extreme ultra-violet region In this investigation Prof Lyman deals with apparatus and methods with the absorption of solids and gases and their emission spectra and with photo-electric and photo-chemical phenomena. The author need not have apologized for the restricted field of his monograph. The careful research here detailed opens up a wide horizon and physicists will welcome a handbook dealing exclusively with so interesting a subject

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JANUARY 23, 1915

Charles Allen Munn President
Frederick Converse Beach Secretary
Orson D Munn Treasurer

All at 361 Broadway New York

Entered at the Post Office of New York N Y
As Second Class Matter

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world

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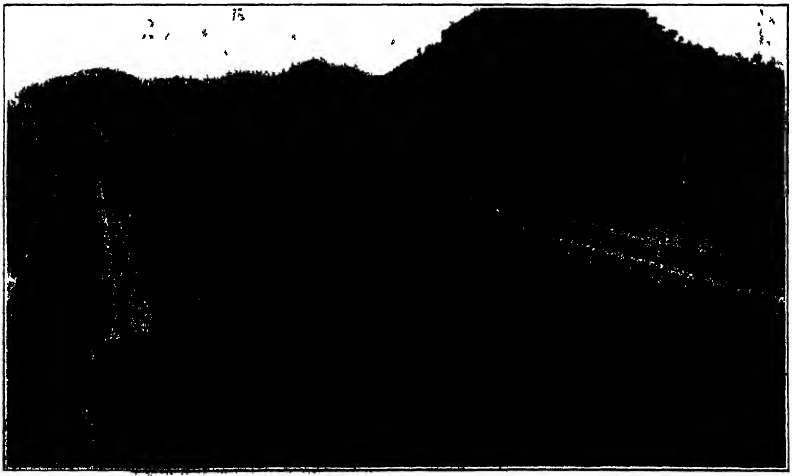
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX] NUMBER [illegible]]

NEW YORK, JANUARY 30, 1915

[10 CENTS A COPY $5.00 A YEAR]

Tender 'Severn' leaving Gatun lock in tow of electric locomotives



A raft of piles from Balboa in the Pedro Miguel locks

TOWING VESSELS THROUGH THE PANAMA CANAL LOCKS BY ELECTRIC POWER.—[See page 72]

Plancton, the Ultimate Food

Vast Resources of the Ocean from Which the Fish Obtain Their Sustenance

One of the most brilliant achievements of modern biology is the demonstration of the vast variety, bulk, and importance of the living creatures, both animal and vegetable, which swarm thickly in the clearest sea-water, and are known collectively by the name of plancton. Since the ocean covers two-thirds of the surface of the globe, and since these aquatic forms of life exist throughout many fathoms of depths, instead of merely in a thin layer of earth and air as do terrestrial creatures, it is obvious that they are enormously superior in numbers and in actual "tonnage."

But the very tiniest of these, the low vegetable forms which derive their nutriment directly from the water and its inorganic constituents, themselves become the food for slightly higher forms of animal life, and these in turn feed still higher forms, so that the humbler marine life is the ultimate provender of those food-fishes which supply so large and increasing a portion of the food of mankind.

Millions of the planctonic creatures are either microscopic in size or so transparent as to be invisible ordinarily. However a pretty experiment demonstrates the presence of some of these tiny forms. It consists in placing a glass dish full of clear sea-water in a dark room and then allowing a beam of light to fall upon it. Just as such a beam will show the motes dancing in air it will show thousands of shining particles which are really living beings dancing in the water.

The planctonic creatures are divided into two great classes, those which are pelagic, i. e., the ones whose whole life, both larval and adult, is spent floating in water, and those which are attached to the submarine soil during part of their existence. The latter are found especially in littoral waters. Marine plancton, which is of course far more important than the fresh water plancton, though this also exists in great quantities, is also divided into the oceanic, found in the deep seas, and the neritic, which is found near shore, that is, above the continental plateau.

Some good work has been done in this country in the study of plancton, especially on the coast of California, but the great authority on the subject is the well-known scientist Dr. Richard of the Marine Museum of Monaco. We are indebted for the facts in this article chiefly to the researches of Dr. Richard as reported in a recent encyclopedic article in *Larousse Mensuel*. The first method of collecting plancton for study was by a net much resembling an ordinary butterfly net attached to a line instead of to a pole and trailed behind a boat. But the resistance of water is so much greater than that of air that the fine silk gauze or bolting-cloth used for the net interfered with the filtering of the water at even a moderate rate of speed. Hence Dr Richard modified the shape of the net by making its length greater and its orifice smaller. This increases the surface of filtration and the plancton collects in the end of the long cigar-shaped net and is examined at leisure in the laboratory.

A very important point is to test the amount of plancton in a given quantity of water. This is accomplished by emptying the plancton into a graduated beaker. At the end of several hours it has collected in the bottom of the beaker and its bulk is indicated by the figure at which it stands. Thus an estimate is readily formed of the comparative alimentary richness of any given area of the sea, information of great practical value in the fisheries industries. But it is likewise highly important to know the nature and habits of the species found, since some of these form the favorite food of sardines, lobsters, crabs, cod, herring, or other of the chief food fishes, and a knowledge of their habits and their habitats is immensely useful to the fisherman who would make a full haul.

Such examination of species is chiefly conducted in the laboratory, but preliminary work can be done on board ship by an apparatus invented by Dr. Richard, which consists of a glass dish filled with the water to be examined, a lense, a mirror inclined at an angle of 45 degrees, and a white screen on which the images of the tiny creatures are thrown; the apparatus is completed by a device which compensates the rolling of the vessel.

It is very beautiful to see how exquisitely the creatures which compose the plancton are adapted to their peculiar mode of existence. The most striking feature of this adaptation is the crystalline transparence of most of them which makes it difficult to distinguish them from the water which surrounds them. "It is very curious to see muscles, cartilages, and teguments which resemble glass without being altered in their functions; they can scarce be distinguished from the water except by mingling therewith some reagent which kills them and coagulates and renders opaque their tissues." A similar modification is the clear blue tint of many of the pelagic creatures which live near the surface. This is a very characteristic case of protective coloring, and is never found in specimens found at great depths where the sun does not penetrate.

Since the tissues of these animals are infiltrated with water they have a density approximately that of the water by which they are surrounded; but since even their very slight excess of density would carry them down sooner or later they are provided with special compensating apparatus. Sometimes they have fins whose force can be exerted in a direction contrary to that of gravity; or they may have floats consisting of a drop of oil or a bubble of air in a contractile sac. Still others have appendages shaped like paddles, or like feathers, whose surface resists the downward pull.

"All these creatures, to diminish their density, have eliminated from the organism the heavy parts—the thick bones, compact shells, resistant carapaces which are borne by their congeners of the littoral and the bottom. Thus one observes very curious creatures among them, whose viscera occupy a comparatively small part of the gelatinous mass of their transparent bodies."

Very often the planctonic animals which live several hundred meters below the surface have developed enormous eyes; their antennae and their claws are elongated also, and the minute organs of sensation which cover their bodies are hypertrophied. The pelagic animals which live at great depths develop "telescopic" eyes, i. e., they are cylindrical instead of globular. This is only found at such depths that only the ultra-violet rays of the solar spectrum can penetrate. Another notable feature is that the otocyst, the organ which replaces the ear in inferior animals, is highly developed and acts as an organ of equilibrium.

Their fecundity is, of course, enormous and the ship "National" on one occasion observed a great swarm or shoal of one variety floating on the surface and no less than 260 kilometers long. Obviously such a huge mass of tempting food material will attract hungry schools of fish, hence it is of interest to learn what conditions the presence or absence of various kinds of plancton in any given locality. It has already been observed that the composition of the plancton in any place varies at different seasons or even different times of the day. Thus they will descend when the surface of the ocean is agitated for their bodies are too delicate to bear violent motion. Rain also drives them down, since they are not fitted for contact with fresh water. Some cannot bear light and fly from the approach of daylight, while others execute the inverse movement. Hence the "catch" of plancton varies according to whether the net is cast by day or by night. Some varieties appear only at certain seasons of the year, which fact may be due to variations in the temperature of the superficial layers of the water; and still others appear only at intervals of several years, for reasons as yet unknown. Such facts as these are of prime importance to the fisherman, and it is hoped that when these movements of plancton are fully understood much of the present uncertainty in the fisheries industry may be eliminated.

Most of the plantonic plants are microscopic algae, a large percentage being composed of immense shoals of diatoms. These are most abundant in the cold waters of the temperate and the polar seas. It has been estimated that a cubic meter of water off the coast of Iceland contains 5 billions of them. Another common species is the peridinians, which are ranked as plants because of the carapace of cellulose, though some of their characteristics relate them to the protozoa.

Among the pelagic protozoa special mention is due to the *foraminifera*. These secrete a tiny shell of calcareous matter, through whose apertures extend the long filament of the animal's gelatinous body. When the animal dies this shell is no longer buoyed up and slowly sinks. More than 150 million square kilometers of the bottom of the sea are thickly carpeted with a mass of these tiny shells. Nearly two-thirds of the bottom of the Atlantic is covered with them. A curious fact is that they are not found below 5,000 meters in depth, because their substance being slightly soluble in water is dissolved by the time it has reached a certain depth. It is of such deposits as these that our sedimentary rocks are made. Similar deposits are made by the species radiolaria, but as their skeleton is silicious it is less soluble and is therefore found in very deep areas of the Pacific ocean. The common phenomenon of phosphorescence in salt water is due to other species, and persons who take sea-baths at night often observe shining flecks like scraps of phosphorus clinging to their garments.

Other varieties are the *coelenters* and the *siphonophores*. Also the larvae of the *echinoderms* and of *sala*. Besides these may be mentioned certain molluses. *Crustacea*, etc., are abundant both in fresh-water and salt-water plancton. "Their small species, especially the *copepods*, swim in huge shoals. They are found in all seas and form the basis of the animal nutriment of marine animals. It is these above all on which the sardine feeds and the movements of shoals of sardines follow those of *copepods* and *peridinians*. Doubtless the presence of the latter is dependent on varying conditions of temperature, salinity, etc., and the apparently recondite labors of the marine geologist may prove of invaluable commercial aid, another argument for the liberal support of pure science.

Much remains to be done in this vast and fertile field of investigation, especially in the study of pelagic plancton both on the surface and in the depths of the sea. In closing, a word must be given to the special net devised by Dr. Richard for obtaining deep sea plancton. This consists of a square frame composed of iron rods, each 4 meters long. To these are attached triangular pieces of cloth of such mesh as is desired, from that as coarse as canvas to that which contains 6,000 apertures to the square centimeter.

These triangles meet at a common apex, thus forming a huge pyramid. This is lowered by a steel cable operated by steam-power. To fish at 6,000 meters the cable must be 10,000 meters long to allow for its oblique line when the boat is moving. When the boat stops the net is drawn up very slowly and carefully. At 5,000 meters depth the column of water above the top of the net would have a volume of 80,000 cubic meters, and every drop of this vast amount must be filtered through the meshes of the net. The resultant catch contains all the plancton existing in that vast bulk. Devices have also been invented for securing the catch from a given layer at a given depth, shutting off the top layers, but as yet have worked imperfectly.

Oil Filters

According to the *London Times* a form of oil filter and drier designed by the British Thomson-Houston Company, of Rugby, is specially intended for the purification of oil used in transformers and other high-tension oil-filled apparatus, though it can also be used for the treatment of many other liquids as well as heavy viscous compounds, the latter being preferably warmed. The importance of dryness in transformer oils is illustrated by the fact that the quantity of water present must not exceed 0.001 per cent in order to obtain a dielectric strength of 40,000 volts in the standard test (0.1 inch between disks 1 inch in diameter), as required for high-tension work. Fine dust, especially metalic, is almost as effective as water in reducing the dielectric strength, and it is, therefore, necessary to remove any sediment which may result from long continued heating, in order to preserve the normal viscosity of the oil and to prevent incrustation of the interior parts of the transformer and the clogging of the oil channels. In the B. T. H. arrangement the oil is pumped under a pressure of 25 to 100 pounds per square inch through layers of pure white blotting paper made principally from wood pulp and supported in a suitable filter press. Most of the solid matter is caught by the first layer of paper, while the water is retained by capillary action in the paper, the capillary attraction between the paper and the water being greater than between the paper and the oil. The presses are made in two standard sizes, one 7-inch, with 14 chambers, having 7 square feet of filtering surface, and the other 12 inches, with 20 chambers, having 30 square feet of surface. Special electric ovens have also been designed for drying the filter paper. The effects of filtering are illustrated by a test carried out on oil which had been in use for about 10 years. Before filtration it broke down at 1,800 volts, with electrodes of 0.05 inch apart; after one filtration it broke down at 10,200 volts; and after a second filtration it withstood 20,000 volts without breaking down.

Importance of Aluminium

In a paper read before the Junior Institute of Engineers, in England, E. N. Munro calls attention to the increasing importance of aluminium. He stated that for electrical purposes aluminium was fast becoming common. Overhead transmission lines constructed in aluminium showed a great saving over equivalent copper lines, a saving of as much as 10 to [illegible] per cent being effected [illegible] of the system adopted. [illegible] aluminium [illegible] Hall in America [illegible] Heroult in France [illegible] metal electrolytically in 1886.

The Function of Enzymes*

Products of Living Cells That Affect the Chemical Operations of Living Matter

By Samuel C Prescott

THE study of the chemical or physiological activity of cells, whether of microbes or of men is at once one of the most interesting and one of the most difficult problems of the biologist, for it seeks to disclose the secrets of life processes How does a disease germ produce its poison, or a yeast cell bring about its characteristic fermentation? How do we carry on those transformations of food material by which beefsteak and bread and butter at once become available sources of energy and matter for our living machine? How does a potato manufacture starch in its leaves transfer it to the growing tubers and there store it up for future use?

In each case by means of enzymes which we may define as the tools of cells and the reagents by which the chemical reactions of cells of all kinds are effected

The term ferments' was first used early in the nineteenth century by Schwann and Berzelius Afterwards the word was used somewhat indiscriminately, meaning either a micro-organism of fermentation or a chemical substance which in some way was related to living cells To distinguish between these the physiologist Kühne suggested the term enzyme to designate the digestive ferments such as pepsin trypsin and ptyalin The word has now been universally accepted as the name of a group of chemical bodies products of living cells which have the peculiar property of effecting the chemical operations of living matter but which do not enter into the final products of these reactions

Chemistry cannot produce enzymes for they are found only as the products of protoplasm of living cells and it makes no difference whether we are dealing with the ultra-microscopic bacterium or the giant redwood or the whale, the chemical activities are due to enzymes Furthermore the same kind of enzyme may be produced by organisms of widely different character as for example the trypsin of certain bacteria of the carnivorous plants like the Venus Fly Trap and of the human intestinal tract

Since the variety of chemical processes carried out by living cells is large in number it follows that the number of enzymes is legion Even the number produced by a minute bacteria cell hardly visible with a high power of the microscope may be several while with organisms of highly specialized form and physiological division of labor the number is greatly increased In man at least fourteen are known to be developed in the alimentary canal and to take part in the process of digestion while if we added all the other chemical changes which may be elaborated in the body as a whole, our catalogue would be greatly increased Moreover we may assume that there are many enzymes which are still unknown for the enzymes may be intra-cellular that is acting only within the cell as well as extra-cellular or extruded outside the cell and so possibly capable of detection The positive knowledge of the action of intra-cellular enzymes is still very meager although when Büchner discovered zymase and a method for its preparation in 1897 the first great step forward in their study was made

What an enzyme really is cannot be exactly stated An enzyme is known only by its reactions By their works ye shall know them is essentially true in the ferment world We cannot even tell their composition or to what class of chemical substances they belong for they have never been obtained in pure condition It is generally assumed however without proof that enzymes are protein-like in character In spite of this indefiniteness and the elusive character of these bodies certain general properties regarding them have become known and on these points all enzymes behave in like manner, although differing distinctly from other chemical substances

We may thus regard enzymes as forming a special and peculiar group of chemical compounds differing in certain ways from other substances, and especially in their relation to the law of mass action as shown by the great disproportion between the amount of the active substance and the amount of material changed. A good example of this is rennet, which it has been stated can coagulate from 300,000 to 800,000 times its weight of casein, without being used up. All enzymes possess the same characteristic but not necessarily in the same degree. The activity is largely dependent upon the physical and chemical conditions of the environment. Thus very slight changes in the reaction of the medium on which an enzyme is acting may control very largely its degree, or make the difference between high efficiency and practical inactivity. Some enzymes require neutral solutions for action others are most vigorous in slightly acid or slightly alkaline media

Similarly temperature may play a very important part in the control of enzyme reaction In this respect these substances behave closely like living cells and like certain kinds of proteins Each enzyme has a maximum a minimum and an optimum temperature of activity just as microbes have and like these if heated above the maximum will be rendered inactive and finally destroyed This thermal death point as it may be called is very near the coagulating point of albumin and not far from the death point of most vegetative bacteria Another similarity to the proteins lies in the fact that both enzymes and albumins are precipitated by concentrated salt solutions such as ammonium sulphate by alcohol and by salts of heavy metals Furthermore they may be more or less completely mechanically precipitated with flocculent or bulky precipitates as by use of phosphoric acid and lime water Certain poisons may also inactivate enzymes Substances which kill living cells like formaldehyde hydrocyanic acid or mercuric chloride will in general kill enzymes provided the solutions used are strong enough and sufficient time is allowed for the destructive action The enzyme has a somewhat greater resistance than has the living cell but the difference is one of degree rather than of kind In fact so closely do enzymes correspond to micro-organisms in behavior toward physical agencies poisons etc that we use the same terminology in discussing them and speak of the poisoning or killing of the enzyme Other substances such as toluene chloroform and a few others permit enzyme reaction but restrain the activity of living cells thus giving a differentiation of great value in studying them

Enzymes also have many properties in common with the *toxins* and so far as body reactions go seem to belong to the same class of organic compounds When a toxin is injected in small amount into the body certain chemical changes are set up and there is soon formed a so-called antitoxin which neutralizes or inactivates the toxin Similarly the action of enzymes upon the tissue of the living body is effected by the secretion of anti enzymes and the injection of foreign proteins into the body may be followed by the manufacture of a precipitin which will precipitate that particular protein and no other This specific action is characteristic of enzymes and toxins as well as of proteins In view of the fact that enzymes and toxins are like proteins the products of living cells it may not be strange that this similarity is found However we are not able to say that enzymes are protein in character but rather that they are found in association with proteins The purest enzymes yet prepared do not give protein reactions Moreover mineral salts seem essential for their action

We may explain the mechanism of fermentation and putrefaction changes on the basis of the enzymes produced by the inciting organisms for in recent years it has been shown that the enzymes carefully prepared and fed from living cells will carry on the same changes with almost mathematical precision In yeast for example Büchner found within the cells an enzyme which could only be extracted by grinding with fine sand and subjecting to enormous pressure but which when thus obtained produced alcohol and carbon dioxide from sugar in exact accordance to the chemical equation which had long been used to represent the fermentation Thus it was shown that intra-cellular enzymes exist and we now believe that many processes taking place in living cells—perhaps all the processes—are the results of enzyme activity

Since the chemical nature of enzymes is so largely unknown, we can classify them only by their action on various compounds It is possible however to group them into the four classes of *hydrolyzing* or causing the addition of water to certain substances Most enzymes acting on carbohydrates are of this class So also are those that affect fats and the majority of those producing known proteolytic changes These are best represented in the processes of digestion A second group are the *Zymases*, or those producing the splitting of bodies into simpler cleavage products without any hydration The alcoholic fermentation is the best known of this class

The remaining two classes are the *oxidizing* and *reducing* enzymes, producing the types of change implied Of the former, the production of vinegar is a familiar example, alcohol being oxidized to acetic acid by an *oxidase* produced by the acetic bacteria Such familiar changes as the darkening of freshly cut surfaces of fruits (apples) or the quick change of color when mushrooms and toadstools are broken also belong to this category The reduction processes are of enormous variety in nature both in plant and animal life While typically distinguished by the reduction of hydrogen peroxide to water and oxygen these Katalases as they are called may also reduce sulphates nitrates and various coloring matters as well as other compounds Upon the activity of enzymes may depend all the complex series of changes oxidations reductions synthetic and analytic changes which characterize the process of growth and decay renovation and destruction in the cell and in tissues The phenomenon on intra-cellular fermentation seems to be closely linked with enzyme activity and the building up and breaking down of protoplasm itself is intimately connected with intra-cellular changes and energy liberation

There is reason to believe that some enzyme actions are like organic chemical reactions reversible Thus maltase will split maltose into two moleculars of dextrose under the ordinary conditions of action If however we add maltase to concentrated dextrose solutions a small amount of maltose (or isomaltose a similar sugar) will be formed the reaction proceeding until a certain equilibrium is established This has not been demonstrated for all enzymes and some eminent authorities divide enzymes into two classes only one of which is catalytic and capable of synthesizing as well as splitting substances while in the other no trace of synthesis has been observed

On the subject of the origin of enzymes and the causes stimulating their activity many interesting observations have been made Some enzymes are produced by cells in such form as to require no further aid to render them active Others require the presence of a specific substance known as an activator The pepsin of the stomach is produced by the cells of the gastric glands as a zymogen called pepsinogen which under the influence of the hydrochloric acid produced at the time the stomach is functioning becomes changed to pepsin We do not know how the enzyme and the acid are associated but we know that the latter is necessary for the production of pepsin and also for its action Bayliss has described another instance in which the activator itself, enterokinase acts as an enzyme upon the zymogen trypsinogen thus producing trypsin but without entering into the actual formation of the finished enzyme—trypsin If this view is correct, we have in effect one enzyme bringing a second into existence In other instances activation is effected by metals as in the laccase the oxidizing enzyme of the lac tree of Asia which requires manganese or by salts such as phosphates as in certain alcoholic fermentations

In spite of the apparent lack of exact knowledge of the composition of enzymes and of all their activities we find in this group of substances agents which are of direct and certain application to industrial processes Breadmaking brewing cheesemaking certain phases of tanning as well as the preparation of lacquers and castor oil are a few of these applications

Here is a field of great promise and infinite interest sure to yield results if investigated patiently and consistently by the scientist who combines a deep knowledge of organic chemistry with an intimate acquaintance with cell behavior and activity and this field of bio-chemistry is sure to find greater favor in the immediate future

* From Science Conspectus.

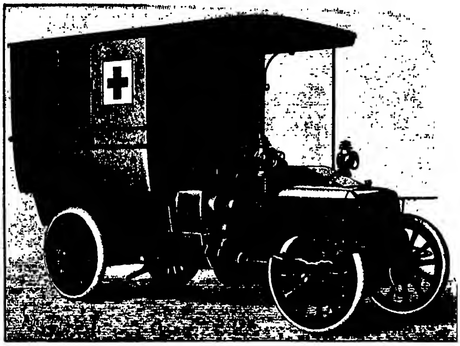
A New Telephone Receiver

AT a recent meeting of the Royal Society a new form of telephone receiver was exhibited that was about the size of a half inch section of a lead pencil The specimen shown was made at the laboratory of the University of Utrecht, under the supervision of Prof. Zwaardemaker and had been in use for several months without showing any signs of deterioration It is stated that in the new instrument the electro-magnet and diaphragm of the ordinary telephone are eliminated, and for them is substituted a loop of very fine platinum wire within a small cover pierced with a minute hole. As currents pass through the wire they cause small increases and decreases of heat and the consequent expansions and contractions of the surrounding air become evident as sound Owing to the smallness of the receiver it can be put in the ear and sounds are not confused by extraneous noises while the faithfulness with which the intonations of the voice are transmitted is remarkable. The whole apparatus is more compact than the ordinary instrument and the cost is low

Roentgenology in War

How Modern Science is Brought to the Field of Action in War

Very soon after the Roentgen rays became known attempts were made to apply this branch of diagnosis to wounds. Such experiments were tried as long ago as 1896 by the Italians in the Abyssinian campaign; then in 1897, during the Greco-Turkish war, Küttner made use of the Roentgen rays in examinations at the Yildiz hospital at Constantinople, as did also Abbott, who was surgeon on the Greek side, at Phalerus. After this work was done on a small scale in the colonial wars of the English, and finally Roentgenology was established on a much stronger basis through its wide use in the Spanish-American war, 1898-1899, and in the Boer war, 1899-1900. The Herero revolt also gave occasion for its employment in the treatment of wounds. Roentgen rays were much used in the Russo-Japanese War, while in the Balkan war there came into active service the most advanced types of portable Roentgen apparatus.



The Gaiffe-Panhard radiographic carriage employed in the great maneuvers of the East in 1904.
M, motor; *E*, starting gear of the dynamo; *D*, dynamo.

An interesting account of the equipment of a military Roentgen outfit, intended for use in the field, is given in *Die Umschau*, by Surgeon-Major Dr. Strauss, head of a Roentgen laboratory, who tells us that a field Roentgen apparatus is decidedly complicated in its make-up. It must be transportable, should meet all the requirements of modern Roentgenology, and requires a large supply of photographic materials as well as a large amount of additional supplies for the taking of photographs, throwing light, etc. It must also have with it a goodly number of extra parts of the apparatus, so that to carry the whole outfit a very large wagon is necessary, as is shown in the cut of the field Roentgen wagon used in the German army. This wagon contains an inductor with a spark 45 centimeters long, which is driven by a current of 20 amperes strength and 65 volts pressure. This current is interrupted by a Wehnelt contact-breaker, the working of the current being regulated by a switchboard. Besides this apparatus the supplementary parts mentioned above are also stored in the wagon. In all field Roentgen outfits the great difficulty is the source of the current. Ordinarily no dependence can be placed on the chance of connection with an electric wire, especially in the eastern seat of war. The current necessary must, therefore, be generated. The only simple way in which this can be done is by a dynamo driven by a benzine motor.

None of the attempts to get around this difficulty have proved really satisfactory. The entire running of the apparatus would be far simpler if it were possible to generate a sufficiently strong current by means of the condenser. Up to the present time, however, the experiments to this end have not been as successful as required for practical use, although Wommelsdorf's labors in this direction have brought the problem nearer solution. The scheme to replace the dynamo and the benzine motor by accumulators must also be abandoned, for after the accumulator is discharged the recharging in the field is an uncertain matter. As a result of all these factors a field Roentgen outfit represents a heavy weight, and consequently there are definite limits to its use. A benzine motor being necessary for the generating of a current, the thought naturally occurred to work out the entire field Roentgen apparatus as an automobile, and thus to unite in ingenious manner the means for generating a current and for moving about. This idea, which at the present time the French have put into practical use, was debated long ago by the Germans, who finally rejected it. The peculiar conditions of a campaign on the eastern border in winter would make the use of an automobile very uncertain, consequently a field Roentgen automobile would frequently be condemned to stand idle. So on this account the Germans decided to place the military Roentgen outfit in a wagon drawn by horses, the wagon externally being somewhat similar to an ambulance.

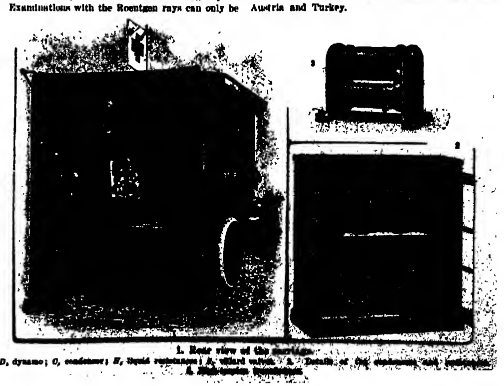
As regards the making of Roentgen-ray examinations in the field, says Dr. Strauss, the many experiences of the campaigns first mentioned show that the Roentgen process is only applicable when it is possible to take definite medical measures. To send the military Roentgen wagon to the spot where first aid is given to the wounded, or to the field hospital, which is often moved five or six times, would be nonsense. All demands that this should be done come from those who neither understand military conditions nor the Roentgen process. Examinations with the Roentgen rays can only be made where quiet and settled conditions prevail. Anything so costly to procure as a field Roentgen outfit should not fall into the hands of the enemy or be destroyed when troops are obliged to fall back. It should also be remembered that the use of the Roentgen rays is a very precise process, and that rough work in the open air without the equipment for a dark room, etc., cannot be thought of. Consequently, these outfits are distributed among the military hospitals. There, where there is quiet and security, the Roentgen process accomplishes positive results.

The chief value in diagnosis of investigation by the Roentgen rays is in the finding of splinters of shot that have remained behind in the body, in the recognition of severe inflammatory conditions in the bony structure, as the dying of some part of a bone or suppuration, and in the determining of injuries to the skull. This naturally brings up the entire question of the value of diagnosis by these rays in internal medicine, as well as, to some degree, of the curative power of the Roentgen rays.

The number of Roentgen outfits taken into the campaign by the German army is relatively large, and the equipment is so complete that salutary work is possible in those parts of the field of war away from ordinary means of communication.

Baskets for German Ammunition

One of the many details developed by the German army is what appears to be a new idea in the rapid handling of ammunition for all classes of artillery. In shipping shells, when they are being sent to the front, it is not customary to box or crate them, and they are by no means easily handled on account of their construction, especially the larger sizes. Moreover, if not protected in some way they are liable to injury. To meet these conditions the Germans have made baskets of various sizes, according to the size of the shell to be handled, the largest size containing a single projectile. Other baskets are made in various shapes, with receptacles for shells and cartridges. All the latest patterns of baskets for transporting shells have eight strips of hard wood, four on the outside and four on the inside, extending from the top to the bottom of the basket. The outside strips protect and strengthen the basket, and the inside ones keep the shell in place. Two strips of canvas belting are attached to a circular leather bottom upon which the shell rests, the outer ends of the strips being fastened together, forming a hold by which the shell is lifted from the basket. Baskets are made in various sizes, some with divisions to accommodate cartridges. The baskets are kept filled with shells and cartridges at the artillery depots, ready for quick shipment to the front. The baskets protect the shells and explosives from contact with hard substances as well as facilitating their rapid handling. Within the last few years upward of 1,500,000 baskets have been made for the German army, and before the war large numbers of baskets were sent to Austria and Turkey.



1. Rear view of the carriage.
D, dynamo; *C*, condenser; *H*, liquid resistance; *V*, Villard valve. 2. Details of the condenser and [illegible]. 3. High-tension transformer.

Effects of Vacuum on Performance of Steam Turbines

In a paper by Mr G Gerald Stoney read before the Institution of Mechanical Engineers discussing the effect of variations of vacuum on steam turbine installations on land and at sea and published in the *London Times* the author said

The degree of vacuum which gives the same velocity ratio at the exhaust end as throughout any given turbine is the vacuum under which the best results are obtained consequently a turbine designed for 29 inch vacuum barometer 30 inches requires more rows of blades or wheels than one designed for 27 inches the number of rows or wheels on a given diameter in each case being proportionate to the British thermal units available in the range between the initial and final pressures and temperatures through which the turbine works There may however, be considerable latitude in the velocity ratio at the exhaust end without seriously affecting the available economy

GAINS DUE TO HIGH VACUUM

The percentage gain due to vacuum depends on the steam conditions, being much more with low-pressure than with high-pressure steam and the gain in British thermal units available is almost independent of the steam conditions In other words for each degree Fahrenheit that the temperature due to the vacuum is reduced there are approximately 1 5 more British thermal units available These gains due to vacuum are wholly attainable when the turbine can be suitably designed but for high-speed large output land turbines allowance must be made for increased terminal losses

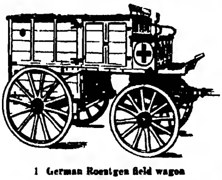
For example in a 3 000 kilowatt land turbine at 3 000 revolutions per minute, with an initial pressure of 175 pounds 150 deg Fahr superheat and a vacuum of 29 inches the consumption will be about 121 pounds per kilowatt-hour and the steam per hour will be 36 000 pounds or 10 pounds per second The volume at exhaust allowing for condensation will be about 6 000 cubic feet per second With present materials available it is not in general customary to go above about 550 feet per second for the mean velocity of the blades at the exhaust end giving a mean diameter of 42 inches and as the blade height in practice cannot be more than one-fifth of this or 8 4 inches the area of the annulus is 7 7 square feet The velocity of the steam leaving the blades through the restricted area will then be 780 feet per second and involve a loss of 12 British thermal units assuming that the velocity ratio and angle of the blades is such that the steam leaves them axially as it should to give the minimum loss Even under these conditions however there is still a gain of 6½ per cent between 28 inches and 29 inches vacuum For still larger powers however, these effects become more pronounced until conditions are eventually reached in this class of turbine having a highly restricted exhaust end when an increase in vacuum causes no gain It is the constant aim of designers to increase the limiting vacuum by using higher blade-speeds, and enabling an exhaust end of larger dimensions to be employed and this is undoubtedly a direction in which increased efficiency in large power high-speed turbines is to be found

The effect of increased blade-speed is very marked as for a given vacuum the reduction in available gain varies inversely as the fourth power of the blade-speed since as the blade-height cannot well be more than one-fifth of the mean diameter of the blades the area at the exhaust will vary as the square of the diameter or as the square of the mean blade velocity Therefore the longitudinal velocity varies inversely as the square of the mean blade velocity or the British thermal units lost inversely as the fourth power Of course, the reduction can be halved by adopting a turbine with double flow at the exhaust, but this often introduces complications although many highly economical land turbines of large power have been designed on these lines Something can also be done by shaping the exhaust suitably so as gradually to reduce the velocity of the steam on leaving the blades

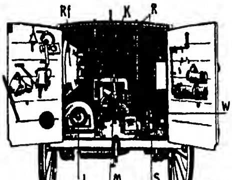
DIRECT-COUPLED AND GEARED TURBINES

Direct-coupled marine turbines especially from considerations of weight and space, are often bladed so as to give uniform velocity ratio at full speed with about 26 inches vacuum, and from various causes many land turbines have been similarly bladed In turbines so bladed and with ordinary steam pressure, it has been found by experiment that the gain per inch of vacuum at full load is, between 26 inches and 27 inches, 4 per cent or 12 British thermal units between 27 inches and 28 inches, 5 per cent, or 17 British thermal units between 28 inches and 28½ inches, 6 per cent, or 22 British thermal units and between 28½ inches and 29 inches 7 per cent, or 27 British thermal units. In the turbines so bladed and at constant speed, as in land work the velocity ratio at the exhaust end would automatically become as high as uniform with the rest of the turbine at about 28 inches, and for quarter-load at about 28¾ inches. Hence in general the theoretical gains will be [illegible] at [illegible] inches

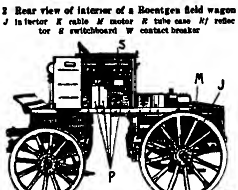
Geared turbines can stand and should be bladed for high vacuum and the blading should be for nearly the highest vacuum obtainable in the waters in which the ship trades as there is but little loss by running a turbine bladed for high vacuum at a lower one For example it should be bladed for 28½ inches to 29 inches the vacuum obtainable in home waters and the like and not for 27½ inches to 28 inches which will be the vacuum obtainable in the tropics with a good condensing plant In such turbines the full theoretical gain due to vacuum will be attained at full speed while at half speed and one-eight power the gain due to increased



1 German Roentgen field wagon



2 Rear view of interior of a Roentgen field wagon
J inductor *K* cable *M* motor *R* tube case *Rf* reflector *S* switchboard *W* contact breaker



3 Side view of interior of a Roentgen field wagon
J inductor *M*, motor *P* photographic apparatus *s* switchboard

vacuum will be somewhat more than that at full speed

In most cases blading a geared turbine for high vacuum as compared with low vacuum adds very little to the weight and generally only necessitates the exhaust end being made somewhat larger It is very important that the exhaust between the turbine blades and the condenser should be free and should be unrestricted so that the loss of vacuum between the last row of blades and the steam space in the condenser should be a minimum This applies to all classes of turbines It is equally important that the loss of vacuum between the steam space in the condenser and the air-pump suction should also be a minimum In other words given a condenser and an air-pump of the highest efficiency the difference in vacuum between the air-pump suction and exhaust end of the turbine should be reduced to an absolute minimum

TREATMENT OF EXHAUST STEAM

In a complete installation, whether land or marine there are many other factors besides the turbine to be taken account of As increase in vacuum is associated with a corresponding lower temperature of condensate it follows that if the vacuum is raised and the condensate is delivered to the boiler at the same temperature at which it leaves the condenser either the quantity of steam generated in the boiler per unit of coal is decreased or the quantity of coal per unit of steam generated is increased In practice, however both on land and at sea the condensate is invariably heated either by the waste gases from the boiler or by the exhaust steam from the auxiliary engines, or by both Land installations usually include an economizer in the boiler uptake, and the practical requirements in such a case is that, in order to prevent sweating on the tubes the feed water should be delivered to the economizer at a temperature of about 120 deg Fahr But even at the highest vacua there is usually sufficient exhaust steam from the auxiliaries to raise the condensate to this temperature so that such a system represents the highest economy attainable with any given plant

Marine installations present a different problem by reason of the large quantity of exhaust steam available from the auxiliary engines and it may here be noted that the heat in exhaust steam is used to the greatest advantage possible when it is re-delivered to the boiler with the feed water It follows that in order to attain maximum economy on shipboard the entire exhaust from auxiliary engines should be condensed by the feed water A perfect installation from this point of view would be one in which the turbine works under the highest attainable vacuum with efficiency and in which the exhaust steam is maintained at such pressure as will enable its heat to be wholly transferred to the feed water In fact the economic pressure for the auxiliaries to exhaust at is that in which the whole of their exhaust can be condensed by the feed Obviously there should be no surplus exhaust and if there is a surplus it should never be discharged into the main condenser because of the highly prejudicial effect of oil on the heat-transferring efficiency of the condenser tubes and on the vacuum

The direction in which progress is to be made on marine turbine installations would therefore appear to be (*a*) High vacuum turbines (*b*) high efficiency condensing plant (*c*) economical auxiliaries and (*d*) efficient exhaust-steam feed heaters In some cases where there is a surplus of auxiliary steam it is turned into the low pressure turbine Here there is an apparent partial recovery of the loss but in practice this arrangement has the defect of fouling both the turbines and the condenser with oil and reducing their efficiency so that the entire power of the turbine may easily be reduced to a far greater extent than it can be increased by the use of such surplus steam If the steam is used in this way it should be very carefully filtered

CONDENSER DESIGN

The effect of reduced conductivity of the condenser such as is caused by air is much more at high rates of condensation than at low showing that the effect of a faulty air-pump or dirty condenser is much more when the rate of condensation is high Approximately also the loss of vacuum below that theoretically obtainable depends only on the rate of condensation and on the amount of air insulation and not on the quantity of circulating water and always assuming a condenser free from oil on the outside of the tubes and scale on the inside there is not much use in having more circulating water than about 60 to 80 times the steam condensed at full load in home waters and the tropics respectively Money put into a condenser of ample size is money well spent Ample surface also gives a good margin to allow of the condenser getting dirty or for overloads

Fire-resisting Wood

The British Fire Prevention Committee have issued a report on a test they carried out on a partition made of wood which had been impregnated by the Oxylene process with the object of making it fire-resisting The partition measured 10 feet by 9 feet, and its head sill side posts and intermediates were constructed of 2 inch by 1¾ inch deal each side being covered with ⅝ inch grooved tongued and beaded boarding in 5-inch widths It was submitted for 45 minutes to temperatures that rose to 1 630 deg Fahr and then water was pumped upon it from a steam fire engine According to the official observations smoke appeared through the joints on the outside after 38 minutes and scorching was noticed at several joints two minutes later while after 44 minutes a glow was visible at four joints Water came through several of the joints when at the end of the test the hose was turned upon the partition which however remained in position Although the resistance of the woodwork did not last long enough by a few minutes to enable the partition to be classed as affording temporary protection under the committee's standards a note prefixed to the report states that the test demonstrates that the impregnating process employed has a retarding effect on combustion and that timber so treated should be a valuable addition to the stock of fire-resisting materials The process consists in submitting wood to a course of steaming vacuum and pressure whereby the sap water air and moisture are removed and replaced by a chemical solution which is preservative antiseptic, non hygroscopic and non-corrosive The water of this solution is then evaporated by placing the wood in drying kilns the chemicals being left embedded throughout the fibers of the wood in minute crystal form On the application of heat the crystals expand and form a glassy coating to the wood this coating excluding the oxygen of the air and preventing combustion.—*London Times*

Iron Manufacture by Electrolysis*

Properties and Industrial Applications of the Product

By L. Guillet

The industrial manufacture of iron by electrolysis is a problem which has engaged attention for many years, but it is only within the last year that it has entered the practical stage. In principle, the method consists in the use of a revolving cathode and a neutral solution of iron salts, maintained in the neutral state by the circulation of the liquid over the surface of the iron. The bath also receives periodic additions of a depolarizing medium, such as oxide of iron, the object of which is to eliminate, at least in part, the hydrogen deposits on the cathode, which injuriously affect the material if present in too large a quantity. By these means it is possible to work with a current of high density (1,000 amperes to the square meter), and an iron of excellent quality is obtained. The process is applicable either to the production of very pure iron, which can compete with the best iron and Swedish iron, or to the direct manufacture of tubes and sheets in the finished state. It has emerged from the laboratory stage, and is now being put into operation on an industrial scale.

Commercial tubes of electrolytic iron.

PROPERTIES OF THE METAL.

Using any pig iron in solution, an electrolytic iron can be obtained of the following average composition, after removal of the gases by annealing:

	Per Cent.
Carbon	0.004
Silicon	0.007
Sulphur	0.006
Phosphorus	0.008

At the present time it is possible to guarantee phosphorus lower than 0.010 per cent. With a density of current of 1,000 amperes per square meter, the yield per kilowatt-year is 2 tons of metal, including the cost of current for the accessory services, particularly for the rotation of the cathodes.

The material in the crude state, that is, in its state on removal from the electrolyte bath, is hard and brittle. In fact, two effects are produced in the process of manufacture. The metal is interstrained and has absorbed gases, particularly hydrogen. On heating in vacuum between 800 and 1,100 deg. Cent. for four hours, and then raising it to the neighborhood of 1,400 deg. Cent. for a further two hours, Sir Robert Hadfield found that 31 grammes of the iron had a volume of 4.8 cubic centimeters and yielded 29.8 cubic centimeters of gas of the following composition:

	By Volume. Per Cent.	By Weight. Per Cent.
Hydrogen	18.8	65.8
Carbon monoxide	7.4	25.7
Carbon dioxide	0.2	0.7
Nitrogen	2.2	7.6
Oxygen	..	..

The presence of carbon monoxide is somewhat noteworthy. On its removal from the electrolyte, the iron is very brittle, and has a Brinell hardness of 193, using a ball of 10 millimeters diameter under a load of 3,000 kilogrammes. The micrographic examination reveals an entirely characteristic structure, consisting of innumerable fine needles, very much resembling martensite.

After annealing for two hours in magnesia at 900 degrees, the iron shows a Brinell hardness of 90. The micrographic structure is perfectly normal. The tensile test gives a breaking strength of 30.9 to 32.8 kilogrammes per square millimeter, and an elongation of 40.2 to 42.1 per cent in the direction of the axis of the tube. Further, the annealed tubes, when subjected to compression tests, can undergo deformation to an extraordinary degree without a sign of any fracture, as shown in one of the illustrations.

INDUSTRIAL APPLICATIONS.

The industrial applications of electrolytic iron fall into three principal categories: (1) the direct manufacture of tubes; (2) the direct manufacture of sheets; (3) the preparation of pure iron as a raw material intended for fusion. There are various other uses of less importance, such as the preparation of rods of very pure iron for autogenous welding.

Tubes.—The manufacture of tubes is being proceeded with on an industrial scale by the Bouchayer & Viallet Company, whose installation is capable of turning out 100 tubes per day. The current practice of this company is to manufacture tubes 4 inches long, 100 to 200 millimeters in diameter, with a thickness of 0.1 to 6 millimeters. Some of these are shown in one of the illustrations. As is well known, all present methods of manufacturing tubes present certain insurmountable difficulties when it is desired to obtain regular thicknesses of less than 6 millimeters. As a general rule, in the products obtained the thickness of the wall is far from constant. With the electrolytic process it is possible to obtain the most satisfactory regularity whatever the thickness, diameter, and length of tube.

The tubes will withstand considerable pressures. Thus, a tube of 100 millimeters diameter and 0.75 millimeter thickness, subjected to 1,200 pounds per square inch, underwent a permanent deformation of a regular character, as if squeezed in a press. Another specimen of the same tube was exposed for two and a half months to a temperature of 120 degrees in a boiler. It was then tested to 1,200 pounds per square inch, but no trace of fracture was perceptible.

Sheets.—The manufacture of sheets is under investigation, but no doubt the researches in the industrial laboratory will lead to a method by which they can be produced commercially. The importance of being able to obtain sheets direct without rolling will be appreciated. The iron is of first-class quality, capable of undergoing very considerable deformations in the cold. Tests on tubes and plates have been made in the draw bench, and it is surprising with what facility the metal can be worked. The material is therefore highly suitable for purposes of stamping, both in the form of plain annealed plates (black plates) or of tinned plate. Finally, on account of their purity, these sheets are especially adaptable for use in the construction of electric machinery. Dr. Max Breslauer of Berlin has demonstrated the important aspect of this question, both from the point of view of magnetic properties and of regularity of thickness and compressive strength. The efficiency of alternating motors and transformers, and also of direct current motors, is increased by using this material in their construction. He concludes that the use of electrolytic iron constitutes a real progress, both as regards hysteresis and permeability. In transformers the saving in weight of material is 33 to 40 per cent. The capacity of alternating motors can be increased by 30 per cent, running at the same temperature, and occupying the same space. In direct current machines, 16 per cent of the iron can be saved.

As a Raw Material for Fusion.—Without doubt electrolytic iron will be able to compete successfully with Swedish iron. The quality is much more regular, and the crude metal, being very brittle, can easily be broken into pieces of any required size, however small, and, at the same time, it can be supplied in suitable thicknesses. The cementation of such products would be more regular than those ordinarily used. Tests made at various steel works have shown that tools and special steels manufactured from this material give results at least equal to those obtained with Swedish iron. The cost price is the only remaining consideration.

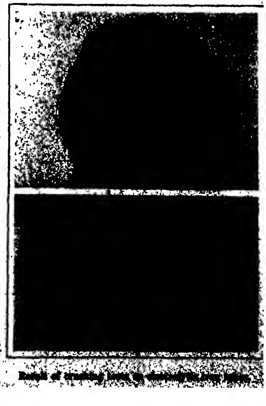
COST OF MANUFACTURE.

The principal factors which make up the cost price are the electric energy and the pig iron. It has already been mentioned that 2 tons of extremely pure iron can be produced per kilowatt-year. Using a current of 500 amperes per square meter, instead of 1,000 amperes, the voltage drops to about one half, and the production per kilowatt-year is nearly doubled. Working with a still lower density, the yield can be even further increased. In countries where the cost of motive power is high, it would pay to work at 500 amperes or even less. It would then be possible to produce 3 to 4 tons, and even more, per kilowatt-year. If the cost of the unit be taken at 1 centime (0.1d.), an ordinary figure in the Alps, and using a current density of 1,000 amperes, the cost of current would not exceed 43 francs per ton of iron produced. Since pig iron is used as the raw material, it may be reckoned that there is about 10 per cent of waste in the form of sludge, graphite, etc. The price of the pig iron would vary according to the locality, and in the mountainous country it would run at about 64 to 88 shillings per ton. The price, however, would be higher in those localities where the electric current was cheapest, and *vice versa*. The average outlay on pig iron per ton of electrolytic iron would therefore be from about 72 to 90 shillings. To this would still have to be added the cost of labor, maintenance, cost of electrolyte, depreciation, and interest on the capital cost of the plant. These various amounts have not yet been definitely ascertained, but the total cost price, based on current prices for material and labor, of the electrolytic iron, in the condition in which it leaves the electrolyte bath, would probably not exceed £6 to £7 12s. per ton, according to the locality.

COMMENTS BY SHERARD COWPER-COLES.

The secretary of the Iron and Steel Institute makes public the following as the substance of a communication sent to him by Sherard Cowper-Coles of Sunbury-on-Thames, England, in which exceptions are taken to some statement in Prof. Guillet's paper:

Mr. Sherard Cowper-Coles wrote that he considered



[illegible]

* From a paper prepared for the abandoned fall meeting of the Iron and Steel Institute at Paris. The author is professor of metallurgy at the Conservatoire National des Arts et Métiers, Paris. Reproduced by courtesy of *The Iron Age*.

the paper by Mr Guillet very misleading in some of its statements. In 1908 he (Mr Cowper-Coles) read a paper before the Iron and Steel Institute entitled "The Production of Finished Iron Sheets and Tubes in One Operation," describing in considerable detail his electrolytic process for the direct production of iron tubes, cylinders, and sheets. In that process a mandrel revolving at a critical speed, so as to give sufficient skin friction between the electrolyte and deposited metal was employed to obtain a close homogeneous deposit and at the same time enable a high current density to be employed, the solution being kept neutral by bringing it in contact with iron oxide as described in Mr Guillet's paper In the following year Mr Boucher approached him (Mr Cowper-Coles) regarding the process and asked if he would grant him a license to work it in France and Switzerland This was done and a small trial plant was thereupon set up in Switzerland and Mr Boucher produced a number of tubes A company was ultimately formed called Le Fer to acquire the license that had been granted to Mr Boucher

Mr Cowper-Coles's object in setting out these facts is to show that all the preliminary work was carried out in Great Britain at great expense and much labor That that was so could hardly be gathered from what he thought was a somewhat ungenerous statement which constituted the only reference to the process in Mr Guillet's paper

In 1907 Mr Cowper-Coles took out a patent involving the use of a 20 per cent solution of sulphocresylate of iron and endeavored to manufacture weldless tubes, using a rotating cylindrical mandrel This process which was analogous to the Elmore process for making copper tubes has not yielded results of much importance '

The Cowper-Coles process he continued is in no way analogous to the Elmore copper process which consists in using an agate burnisher He thought it should be known that the process described in Mr Guillet's paper had been worked out in England and that works are to be erected in the Midlands to carry out the process on a commercial scale He (Mr Cowper-Coles) had all the necessary documents for proving the statements he had given

Business Aspect of the Kelp Proposition*

By Frederic P Dewey

It is thoroughly well established that the giant kelps of the Pacific provide an enormous store of KCl Various papers have appeared upon the broad general aspect of the question but for the most part they have dealt in glittering generalities and many of them have started in the middle of the proposition Many writers neglect or slur over the gathering and preliminary drying of the kelp and base their real consideration of the subject upon the air-dried material This is very attractive and easy to do but the cost of the air-dried kelp is a most serious business consideration

There are various technical and business problems connected with the matter Without in the least doubting the eventual solution of these problems it may be said with entire safety that their solution with financial profit will require the expenditure of much time and money under the best technical and business direction and that it must be several years before KCl from kelp can become a commercial commodity if it ever does

The consideration of the subject divides itself naturally under the following heads

Harvesting the kelp.
Air-drying
Oven-drying
Distillation.
Crystallizing KCl
Marketing.

To start with the growing kelp. How can it be harvested?

It will be an entirely new industry and manifestly various machines of different types will have to be constructed and subjected to actual practical tests before an efficient and economical machine is secured Dr Cameron has suggested 1 000,000 tons of KCl as a conservative annual yield. This would mean the harvesting of approximately 30,000,000 tons of kelp This harvesting cannot extend over the whole year Just how long it may last cannot yet be definitely known, but in any event the vast machinery required to harvest 30,000,000 tons in a short season must stand idle a good part of the year at a heavy interest charge against the product.

Having brought the kelp to shore it must be dried to produce a ton of KCl, approximately 27 tons of water must be evaporated. Clearly the most inexpensive natural means for drying must be adopted, but even this would require the construction of drying sheds covering an enormous area and the building of especially designed machinery to distribute the wet kelp on the drying shelves and to gather up the dried stuff As with the harvesting machinery these sheds and machinery must remain unemployed a good part of the year

There is however a limit to the extent that natural drying in open sheds can be carried When about 25 tons of our 27 tons of water have been evaporated provision must be made to protect the efflorescing KCl which will soon be produced on further drying This will require the application of artificial heat. It may possibly be assumed that this can be obtained from the kelp itself in a subsequent operation By proper oven drying it is possible to recover 40-50 per cent of the KCl as effloresced salt by simply shaking it off from the dried kelp

The recovery of the balance of the KCl from the dried and shaken kelp requires the breaking up of the organic matter of the kelp body and this must be done with as full as possible utilization of its value Simple burning with the utilization of its heat value only will not be sufficient, even if we now had a furnace adapted to avoid inclosing unburned material in the inorganic salts by sintering and to avoid undue loss of KCl by volatilization

At present there does not seem to be any method available for this part of the work except destructive distillation with the recovery of the condensable by products and the utilization of the gas first to heat the retorts and secondly for the oven drying of the kelp as far as may be Probably there are no technical difficulties in this operation but it must be remembered that only about half of the weight including the effloresced KCl of the oven dried kelp is organic matter In other words broadly speaking in the production of one ton of KCl only one ton of organic matter is available for the production of by products of distillation On the other hand the total production of such by products in the recovery of 1 000 000 tons of KCl would be so large that much of them would have to be transported long distances to find a market and therefore the profit of the operation would largely depend upon freight conditions

Undoubtedly a limited amount of the residue from the retorts could find direct application as a fertilizer within a certain radius but the real market for KCl is on the Atlantic coast and under the present freight conditions of 80 cents per 100 pounds the KCl must be dissolved and recrystallized Upon the opening of the Panama Canal and the expected halving of the freight rates the distillation residue might possibly better be shipped direct

The mother liquors from the recrystallizing of the KCl will contain iodine and when sufficiently enriched they may be treated for the recovery of this element

It would be a liberal estimate to assume that the by products recovered including the iodine would have a value sufficient to pay for all of the operations upon the air-dried kelp If we do this and also assume that after sufficient trial and development of the necessary machinery the kelp can be harvested for 25 cents per ton and air dried for 15 cents per ton more a ton of KCl laid down on the Atlantic coast would cost $28 as follows

Harvesting 30 tons at 25 cents	$7 50
Air drying 30 tons at 15 cents	4 50
Freight 1 ton at 80 cents per 100 pounds	16 00
	$28 00

On the completion of the Panama Canal it is expected that the freight will come down to $8 per ton but the present prices of KCl must be very profitable to the German Potash Syndicate and if actually faced with the possible loss of its American trade the prices would undoubtedly be reduced This reduction might even wipe out the advantage of the low water freight.

In conclusion it would appear that the feldspars have not yet been displaced by the kelps as a possible source of potash

* From the Journal of Industrial and Engineering Chemistry.

Parsons Marine Turbines

The total horse-power of marine turbines of the Parsons type completed and under construction in England and elsewhere amounts to about 12 360 000 horse-power an increase during the last 12 months of about 1 760 000 horse-power, according to a statement in the *London Times* Of the total nearly 10 520 000 horse-power is or will be, employed for the propulsion of warships and over 1 800 000 horse-power in mercantile vessels and yachts. The use of geared turbine machinery for ship propulsion is extending rapidly and 126 vessels built or building are wholly or partly fitted with such machinery of an aggregate of about 1 000 000 horse-power These include 62 vessels of 620 000 horse-power ordered during the past year by the Cunard White Star Canadian Pacific Railway, Union of New Zealand, Ellerman, and other lines.

New Hydrogen X-Ray Tube

By H Clyde Snook

Following extended research work in the Snook Roentgen laboratories at Philadelphia Pa comes the announcement of the development of a new type of X ray tube known as the hydrogen tube Results from its use in a number of disinterested Roentgenological laboratories over a period of several months would seem to indicate that the new type of tube possesses important points of superiority over other X ray tubes in use at the present time

One of the most frequent and annoying defects in X ray tube construction in the past has been the difficulty encountered in adjusting the vacuum to a satisfactory working condition The most striking characteristic of the new hydrogen X ray tube is found in the fact that it can be regulated either up or down as to vacuum both accurately and quickly

The Snook Kelly hydrogen X ray tube.

The vacuum is lowered by means of the osmosis of chemically pure hydrogen through a metallic tube closed at one end which acts as an osmotic membrane when heated to redness This metal tube is sealed into the main wall of the vacuum chamber its open end communicating with the vacuum Its closed and protrudes into a body of hydrogen contained within a small glass chamber attached to the bulb proper The metal tube is heated to redness by passing the current across a short spark gap

To raise the vacuum a similar tube within the raising attachment is heated to redness by the same means Although under normal working conditions the hydrogen pressure within the vacuum (so called) is but 0001 to 000001 millimeter of mercury absolute pressure it behaves according to the well known principle that gases act like vacuums to each other Atmospheric air is excluded from the vacuum by the metallic tube—yet when the tube is heated as described above, hydrogen is discharged osmotically into the atmosphere by its own pressure Hydrogen in minute quantities, therefore actually passes outward from the vacuum when the raising attachment is in operation The vacuum of the tube is thereby raised in accordance with the length of time the operation is continued

Roentgenologists report that the hydrogen tube displays marked stability and disinclination toward heating, due presumably to the fact that hydrogen possesses the lowest atomic weight of all known gases and displays little chemical avidity for most metallic substances Extraordinary penetration has also been noted, comparative radiograms showing one Benoist number higher than with any other type of tube.

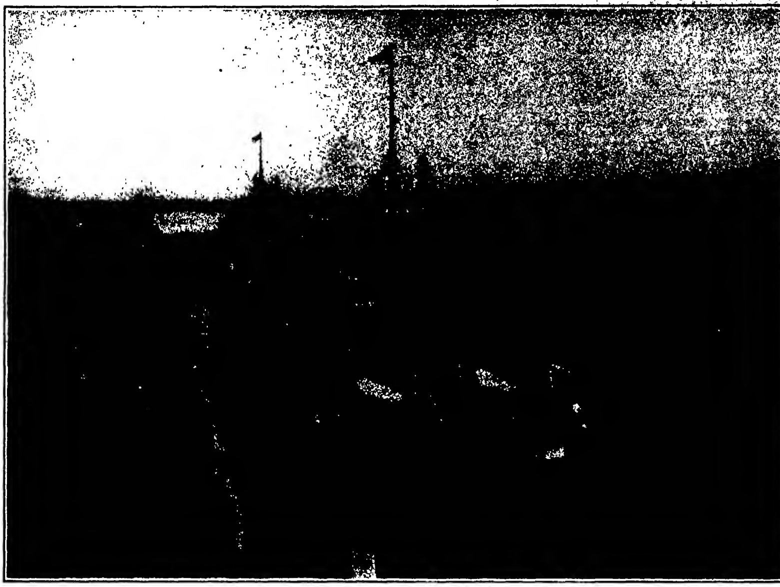
Greater efficiency more uniform result and longer life appear therefore to be the advantages of the hydrogen tube as demonstrated to date

Simultaneously there has been evolved, in the same laboratories an air-cooled type of hydrogen tube with its vacuum subject to regulation by the same means as the standard type referred to above By the use of the air cooled hydrogen tube long fluoroscopic work may be punctuated by making radiograms and administering X ray therapy in massive doses as frequently as the operator may desire

The hydrogen tube is the result of joint work by Mr H Clyde Snook and Mr Edwin W Kelly

Electro-chemical Generators

The Neuhausen Aluminium Works recently ordered three electric generators for an increase in their large plant at Chippis in the Swiss region These machines are built by the well known Oerlikon Works and are to be ranked among the largest yet to be constructed for electro-chemical use being of 2 650 kilowatt size or 3 550 horse power Such machines deliver as much as 8 000 amperes at a tension of 340 volts, and the standard speed is 300 revolutions per minute The generator in each case is direct coupled to a hydraulic turbine, and it is built to stand an overload up as high as 3,000 kilowatts while if necessary the speed can be increased to nearly twice the standard or to 540 revolutions per minute As far as we know the present machines appear to be not only the first to be built, at least in Europe for such a large output and as heavy a current with a relatively high speed but appear even to be the largest generators yet to be built on this side for electro-chemical purposes.



Vessel in the upper Gatun lock as seen from the balcony of the control house.

Electric Towing in the Panama Canal Locks

Ingenious System and Novel Electric Locomotives

INVESTIGATIONS of collisions between ships and lock gates invariably show that "there was a misunderstanding in signals between the captain and engineer." Bearing in mind that the engineer of a ship is so situated that he does not know the exact position of the ship, with respect to the lock, he cannot check his actions by the probable result. A system, therefore, which permits checking the movement of the ship with the signal given by the pilot or captain of the ship, will eliminate improper manipulations to a very great extent.

Various systems are in vogue at drydocks, which are based on the principle that the operator sees the result of his action. The employment of winches, or capstans, has been looked upon with a great deal of favor. These are usually placed at intervals along the dock walls, and the lines from the ship are carried forward to the successive capstans as the ship advances. Such a system involves the risk of the ship not being properly safeguarded when the lines are transferred to successive capstans. An improvement has been made by the installation of a capstan at the head of the dock, centrally located, and used for imparting a straight motion to the ship. Numerous lines from the ship to the dock wall are carried by men; and the capstans are employed to counteract any wind pressure, currents, etc., and assist generally in maneuvering the ship. While an improvement over former methods, it did not, however, possess the flexibility and reliability required for the operation of the locks of the Panama Canal. Neither would it have eliminated the breaking of the lines at critical moments, which is regarded as one of the essential requirements in successfully handling ships in canal locks.

After a very thorough study of the entire problem of maneuvering ships through the locks of the canal, it became evident that they should not proceed through the locks under their own power, and that a substitute for the ship's power should embrace the following requirements:

(a) Ability to place the ship in proper relation to the lock.

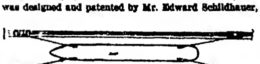
(b) Capability of keeping the ship to its course.

(c) Accelerating and retarding the ship without rupturing the lines.

(d) The lines when once attached should be used without change for lockage in flight.

(e) A small number of skilled operators rather than a large number of unskilled men to co-ordinate.

The towing system described in the following pages was designed and patented by Mr. Edward Schildhauer,



Method of attaching the electric locomotives to a vessel for towing through a lock.

electrical and mechanical engineer of the Isthmian Canal Commission; and the forty towing locomotives and all the electrical apparatus for operating the locks, were built by the General Electric Company.

TOWING SYSTEM.

In passing through the canal from the Atlantic to the Pacific, a vessel will enter the approach channel in Limon Bay, which extends to Gatun, a distance of about 7 miles. At Gatun it will enter a series of three locks in flight and be raised 85 feet to the level of Gatun Lake. It may then steam at full speed through the channel in this lake, for a distance of 24 miles, to Bas Obispo, where it will enter the Culebra Cut. It will pass through this cut, which has a length of nine miles, and reach Pedro Miguel, where it will enter a lock and be lowered 30 feet. Then it will pass through Miraflores Lake for a distance of 1½ miles, until it reaches Miraflores, where it will be lowered 55 feet through two locks, to the sea level, after which it passes out into the Pacific through an 8½-mile channel.

The main features of all the lock sites are identical; and the following brief description of the Gatun Locks, with special reference to the arrangement of the towing tracks, ship channels, inclines, and approaches, gives a conception of the towing scheme.

There are two ship channels, one for traffic in each direction, which are separated by a center wall, the total length of which is 6,330 feet. There are two systems of tracks, one for towing and the other for the return of the locomotive when returning idle. This, however, refers only to the outer walls. For the center wall there is only one return track in common for both the towing tracks. The towing tracks are naturally placed next to the channel side, and the system of towing requires normally not less than four locomotives running along the lock walls. Two of them are opposite each other in advance of the vessel, and two run opposite each other following the vessel, as seen in line cut on this page. The number of locomotives is increased when the tonnage of the ship demands it.

Cables extend from the forward locomotives and connect with the port and starboard sides, respectively, of the vessel near the bow, and other cables connect the rear locomotives with the port and starboard quarters of the vessel. The lengths of the various cables are adjusted by a special winding drum on the locomotive to place the vessel substantially in mid-channel. When the leading locomotives are started, they will tow the vessel; while the trailing locomotives will follow and keep all the cables taut. By changing the lengths of the rear cables, the vessel can be guided; and to stop the vessel, all the locomotives are slowed down and stopped, thus bringing the rear locomotives in action to retard the ship. Therefore, the vessel is always under complete control quite independent of its own power, and the danger of injury to the lock walls and gates is very greatly lessened.

The illustrations show how effectively the four locomotives keep the vessel under control and in the center of the channel, and give a general idea of the method of handling vessels. They also show general views of the lock walls, towing tracks, and the inclines, the steepness of the latter being especially noticeable.

The towing [illegible]

extending the entire length of the track and located centrally with respect to the running rails. It is through this rack rail that the locomotive exerts the traction necessary for propelling large ships and climbing the steep inclines.

A rack rail is also provided on short portions of the return track so as to lower the locomotives safely from one level to the next. The steepest slope is 24 degrees, or 44 per cent, hence the need will be seen for rack rail even on the return track, it being noted that any traction locomotive with the usual wheel drive, even with the brakes set, would begin to slide on a 10 per cent grade, and, therefore, could not be controlled. With a rack rail, however, traction is limited only by the capacity of the driving motors and not by the adhesion of the wheel treads on the rails.

The rack rail is of the shrouded type, and each tooth space has a drain hole cast in the bottom so as to carry off water and other accumulations to suitable drain pipes or ducts set in the concrete of the walls. A further feature of the rack rail is the projecting edges, which permit thrust wheels attached to the locomotive to run along the under side and prevent overturning of the locomotive, in case some unforeseen operating condition should produce an excessive pull on the towline. These thrust wheels serve to counteract the lateral component of the towline pull and the flanges act for emergency only, as the weight of the locomotive is, however, sufficient to prevent overturning with a normal pull of 25,000 pounds on the towline.

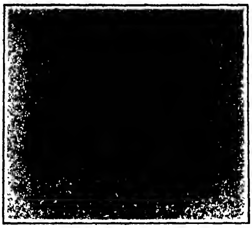
Three-phase, 25-cycle, 220-volt alternating current is used for operating the locomotives, and the current is supplied to the locomotives through an underground contact system. Two T-rails form two legs of the three-phase circuit and the third leg is formed by the main track rails. A specially designed contact plow slides between the two "T" conductors and transmits the power from the rails to the locomotive. This contact plow also passes through the slot opening in the conduit cover and is flexibly connected to the locomotive in such a manner as to follow all irregularities in the tracks and crossovers, and, therefore, insures a continuous supply of power.

LOCOMOTIVE DESIGN.

The working parts of the locomotive are supported by two longitudinal upright side frames of cast steel, connected by transverse beams. These frames are in effect deep rigid trusses, having upper and lower members connected by posts and diagonal braces. The pedestals for the wheel axles are of the usual locomotive type. Springs are interposed between the tops of the journal boxes and the tops of the pedestals, and the locomotive is thus mounted upon four wheels, the wheelbase being 12 feet, and the overall length of the locomotive over 32 feet.

Each axle is driven by its own independent motor; and, as the construction is identical at both ends of the machine, a description of one will suffice for both.

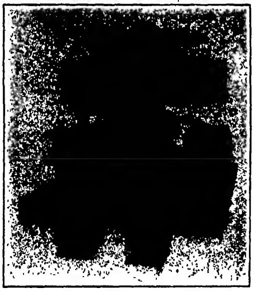
The motor is of the three-phase, slip-ring type, inclosed and identical to the rugged steel mill design. The motor is carried on a pair of cast steel suspension brackets, which are journaled on the wheel axle at one end, and located just inside the wheel on either end of the axle. The other ends of these brackets are connected by yielding supports to one of the cross members of the main frame of the locomotive. These brackets



Traction motor unit of one of the Panama electric locomotives.

also carry two countershafts with the necessary gearing and clutches for transmitting the power from the motor to the wheel axle, with the proper reduction of speed. On the wheel axle is keyed a gear wheel, through which the locomotive can be driven by the traction of the wheels on the rails. The wheel axle also carries a loose sleeve on which is mounted a gear wheel meshing with the transmission gear from the motor, and also the heavy cog wheel that engages with the track rack for propelling the locomotive when engaged in towing. On the second countershaft are arranged clutches by means of which the power can be transmitted either to the wheels for traction running or to the rack pinion. The locomotive is operated on the traction only when running without load and between inclines.

The two traction motors are controlled by suitable controllers installed in the cabs at the ends of the locomotives; and the circuits are such that both motors can be controlled from either cab, and can be operated singly or in multiple as desired.



Mechanism of the windlas that handles the towing cable.

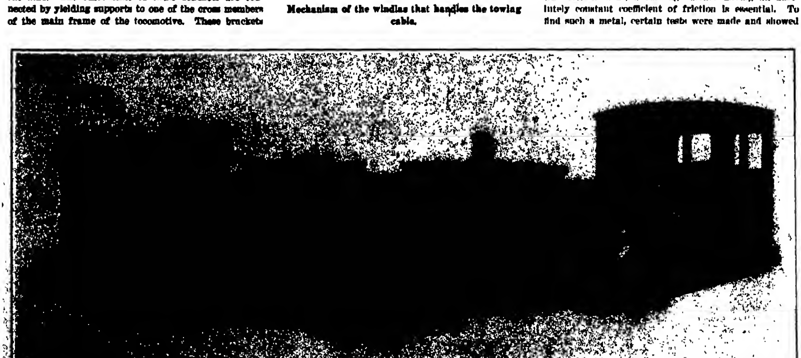
In connection with each motor a powerful brake is installed; and, as during operation the motors are at all times geared either to the axles or to the cog wheels, the truck wheels are not provided with any brake rigging.

These brakes are operated by a solenoid, the winding of which is in circuit with the controller of the motors, so that when the current is turned on to energize the motor windings, the solenoid will lift its core and thereby release the brakes. The first point of the controller raises the brakes without applying power to the motors, thereby providing a coasting point. But should the motor current be shut off, either intentionally or accidentally, the core will instantly drop by gravity and its weight will exert a powerful leverage upon the brake levers to stop the motor and the locomotive. This action occurs simultaneously on both motors, and brake action is powerful enough to stop the locomotive within two revolutions of the wheels.

In addition to this automatic brake, means are provided for applying the brakes manually in order to supplement the action of the automatic feature, if necessary, when descending a grade or where approaching a rack rail.

Passing now to the features which render the locomotive peculiarly adapted for towing purposes, it is observed that there is a large horizontal drum mounted above the body of the locomotive at its middle length, which handles the towing cable that is wound upon it. This drum is carried on a heavy tubular column that is fixed in a substantial pedestal built into the main frame of the locomotive. Below the drum, and mounted on the same column, is a large internally geared wheel, which is connected to the drum by a slip friction clutch, consisting of a steel disk held between two alloy rings with a yielding pressure produced by a series of coiled springs. Two separate electric motors are provided for operating this towing drum, one driving through bevel and spur gearing to the large internally geared wheel, which is for fast coiling in or paying out the cable. The other motor drives through a worm gear, and thence by a spur gear onto the same internally geared wheel, clutched with the towing drum, and is used for taking in slack of the cable, and controlling vessels when towing. The fast running gear is always connected, but the slow working power gear is connected by means of a clutch, which is thrown out automatically by a solenoid that is energized by the movement of the controller governing the fast winding motor. The first point of the controller energizes the solenoid, and frees the clutch of the power gear, and the second point starts the coiling motor.

One of the most important parts of the locomotive is the "slip-friction" device consisting of the two special alloy rings, and the steel disk fastened to the rope drum, the amount of tension on the tow line being adjusted by the pressure between these three disks, which is obtained by tightening the spiral springs on the clamping ring. In order, therefore, to make the slipping tension of the towline proportional to the pressure between the friction disks, a rubbing surface having an absolutely constant coefficient of friction is essential. To find such a metal, certain tests were made and showed



Electric towing locomotive with casing removed, showing its construction.

that the low friction metal, having a friction coefficient of 0.1, is practically constant under all pressures and condition of the surfaces, and, therefore, was selected for the work. This metal also showed but very little difference in coefficient between starting and running. The results of the special tests were furthermore amply verified by the final test of the friction disks of each machine under full rated towline pull of 25,000 pounds. All forty machines were given this slip test twenty-five times from each cab, and all passed the Government requirement not to exceed a variation of 5 per cent above or below the normal of 25,000 pounds.

In connection with the slip test, further data on the slow winding motor was obtained. The winding motor is a 20 horse-power (one-hour rating), three-phase, high torque, squirrel cage type, induction motor controlled from a drum type reversible controller in either of the two cabs. And it has ample power to take care of any sudden pull on the towline up to 40,000 pounds, which is well above the normal requirement of 25,000 pounds. The speed of winding is at the average rate of 12 feet per minute.

The rapid-coiling motor is permanently geared to the drum, and is of the same type, size and capacity as the winding motor. It is subjected to its maximum load when accelerating the heavy drum to the high speed required for coiling or paying out the rope, this being sixteen times the slow winding speed at full load, or about 200 feet per minute.

The slow-winding and the rapid-coiling motors are operated by similar controllers and the circuits electrically interlocked so as to prohibit application of power to either motor unless the controller of the other motor is in the "off" position.

Each of the two main traction motors has a rating of 75 horse-power, and is of the slip ring induction type, operated by a system of contactors with master controller in each cab. The motors, by means of the change in gearing from straight traction to rack rail towing previously described, drive the locomotive at a speed of 2 miles per hour when towing and 5 miles per hour when returning idle. These motors act as induction generators running above synchronous speed when the locomotive is passing down the steep inclines and thereby exert a retarding brake effect to keep the speed uniform.

Space does not permit of a detailed description of the locomotive control apparatus, but a fairly good idea will be had by reference to one of the illustrations.

SUMMARY.

The towing locomotives, as described and illustrated, possess the following operating characteristics:

1. While towing, the speed can be regular from zero miles to two miles per hour.

2. While running idle, the speed can be regulated from zero to five miles per hour, permitting return trips at increased speed.

3. The windlass will pay out or wind in cable at the low rope speed and at the full tow line pull of [illegible] pounds, either when the locomotive is running or at rest.

4. The windlass will pay out or coil in cable at the high rope speed with the tow line taut, either when the locomotive is running or at rest.

5. The windlass is equipped with a safety friction device, which is adjustable to any predetermined value of the tow line pull.

The first impression may be gathered that these machines are somewhat complicated; but, considering their many functions and the great flexibility for performing them, the design is in reality peculiarly simple. The locomotives have fully demonstrated in actual operation that the requirements contemplated by the Isthmian Canal Commission have been successfully met.

The locomotives have a net weight of 86,800 pounds and a gross shipping weight of 92,500 pounds.

During the first three months of commercial operation of the canal, from August 15 to November 15, the cargo transported through the canal and towed through the locks by the locomotives amounted to 1,079,521 tons. During the fiscal year ending June 30, 1914, the Panama railroad carried 643,178 tons of through freight between the two seaboards, and in the preceding fiscal year 594,040 tons. From this it is seen that between six and seven times as much cargo is passing over the Isthmus now as passed over this route when goods were trans-shipped by rail.

The Hygienic Home

Some Facts About Ventilation and Fresh Air

By Dr. John B. Todd

The home is the foundation of all society; its organization is the objective realization of the wisdom and culture of its founders. The ideal home is that in which, with the means available, there is an adjustment of environment that will result in health, comfort and future development of all members of the family. In the establishment of an ideal home it is not so much what one does, or does not do, but rather whether in a given environment and within one's means one does really those things that count for health and comfort.

One of the primal conditions necessary for an ideal home is the perfect health of all its members. The first wealth is health, for while there are exceptional cases where an indomitable will is able to overcome the handicap of ill-health—as in the case of the illustrious Darwin—still, with perfect health much more could be accomplished. Of the conditions in a home that are factors in producing ill health and disease, the matter of ventilation is very important. Probably poor ventilation in houses, schools, churches and all other indoor places where people spend more or less of their time, is the cause of more deaths and more ill-health than all of the wars. The effect of living in ill-ventilated rooms is very insidious and slow to be noticed, but it is none the less fatal in its results. Sanitarians have made many experiments trying to find out just what it is in bad air that is bad, but their results so far have been unavailing. Their methods are too clumsy. According to their beliefs carbon dioxide—the product of respiration—is not harmful. The foul smelling odors that we notice in close rooms produce no ill effects, rebreathing air is not unsanitary, that the bacteria we take in through the air is of a negligible quantity, that the breathing of dusty air is not bad unless in some trades, as grinders of metals, pottery, etc.

The fallacy is in trying to find bad air by considering and excluding the constituents one by one. In the same way there is no such thing as a wagon, for when we inquire:

Is the pole the wagon?
No.
Is the box the wagon?
No.
Is the seat the wagon?
No.
Is the wheel the wagon?
No.
Is the axle the wagon?
No

we fail to find the wagon; but when one is knocked down and run over by a wagon, there is no question of its existence. Thus when we consider the diseased conditions that exist among people who habitually breathe bad air, there is no doubt of its reality. First, we find a slow but steady lowering of resistance, the color of the skin is pale and not of the clear, ruddy tinge of people living out of doors, there is sub-oxidation, the stale indoor oxygen has lost its vitality, and in consequence they become easily fatigued. Then anaemia follows as the precursor to a host of diseases; bronchitis, tuberculosis, laryngitis, rheumatism, and diseases of the digestive system. Price examined 1,413 workers in cellar bakeries and the best tailor shops, and found over two-thirds diseased.

From all these facts it becomes very evident that we need fresh indoor air—air that has had its oxygen made active by the actinic rays of the sun and the buffeting of storms and winds. In the ideal home the problem is, first, to build in a manner that our houses are cold-proof, and therefore it becomes a matter of better architecture. From 25 to 50 per cent of the fuel we burn is wasted to balance the heat loss from our windows, walls and floors. If the heating problem were only to warm the air in our homes, the cost of fuel would be insignificant.

We want windows in great plenty, for light is as necessary as air for healthful rooms, but the heat loss from the windows is enormous. A room inclosed by glass but with no heat is as cold as the outside, and added to the coldness is the stale, dead air with its inactive oxygen. This is the reason of the failure of glass-inclosed sleeping-porches. Air of itself is a nonconductor of heat and we have only to build our homes with two or three air spaces in the walls to make them practically cold proof. Of course all windows, except those having fresh air screens, should have perfect fitting storm sash, and the floors should have a nonconductor filling between the joists. The extra expense of this construction would be returned a hundred fold in health, comfort and money saved. Then, no matter what heating and ventilating system you have, there should be several windows fitted with fresh air screens.[1] These are wood frames made to fit closely the window frame opposite the lower sash in such a manner that all openings for drafts are closed. This frame is covered with a medium quality of unbleached cotton cloth. The lower window is left free and can be raised and lowered as occasion may require. When the window is raised the screen acts as a permeable membrane and allows the fresh air to slowly diffuse into the room and permits no draughts. There is not a day during the cold months of the year when these fresh air screens cannot be used at longer or shorter intervals; and another great benefit from their use is that the air is filtered and dust-free. Dusty air is one of the factors that causes disease and we have greatly under-estimated the evil effects of breathing dust laden air.

There is one part of the home in which we spend one-third or more of our lives, which should receive our earnest consideration to render it sanitary in every respect, and that is the sleeping room. If there is any part of the 24 hours in which we want to be comfortable, it is when we retire to woo sweet sleep, and there is also no part of our time when we really need fresh air and live oxygen as much as we do here, that we may arise refreshed and vigorous. Too often we have not been able to reconcile the idea of comfort and fresh air, and we have taken comfort and let the fresh air go.

However, it is possible and perfectly practical to sleep in comfort during the winter and at the same time have our sleeping room filled with sweet, fresh air. We have only to place a properly constructed fresh air screen opposite the lower sash in one or two windows, then with the windows raised at night we can sleep in perfect safety with the room filled with fresh, invigorating air, and one will arise in the morning with renewed energy. There will be no draughts; rain or snow cannot come in, and the room will not seem cold. Some mothers will claim that this is best for adults, but that it will not do for small children, as they will get uncovered and take cold. Many of these same mothers have learned that it is beneficial for the baby to sleep out of doors in the baby carriage during the day, even through the coldest weather, when the child will sleep quietly and never disarrange the clothing. A little thought reveals the fact that children kick off the clothing nights because they are uncomfortably warm in the heated, close, stuffy sleeping rooms, and that children sleeping under these conditions are habitually getting cold. What we call colds is a germ infection, and hot, stuffy sleeping rooms furnish favorable conditions for its development, while sleeping in cool, fresh air develops the greatest possible resistance to the infection. Mothers should use their reason to fortify their courage, and provide fresh air screens for the children's sleeping rooms. They will not kick off the bedding, but instead will cuddle down and sleep quietly. Their resistance to colds and infections will be increased and they will make more vigorous growth.

If there is any occasion in our lives when we require fresh air more than another it is when we are confined to our bed by reason of illness. It is at this time that the use of fresh air screens gives the greatest comfort and furnishes the greatest aid to recovery. Stubborn, desperate cases of anaemia have much greater chance to mend as soon as continuous fresh air conditions are provided. In pneumonia it is well known that the comfort and condition of the patient are improved under fresh air conditions, and the chances of recovery greatly increased.

We all have learned by personal experience to appreciate the comfort and benefit of fresh air living. We may read and have our reason convinced, our friends may talk fresh air until we have not an objection to propose, still, until our knowledge comes from personal experience, it is of no value to us in our lives. You should acquire that personal experience by having at least one window in your sleeping room fitted with a properly made fresh air screen, for you will quickly perceive the benefit derived, and see the want of more screens. When actual knowledge is acquired in this manner, those who can do so will be satisfied with nothing less than an outside screened sleeping room, which is the greatest convenience, luxury and necessity of an ideal home. All the bad dust is excluded from the home, and the actual housework is very much lessened. The temperature in a sleeping porch during cold weather will be from 12 to 20 deg. Fahr. warmer than the outside. When the outside temperature reaches 45 or 50 degrees, a person will not feel comfortable without an outside door open.

The universal living in fresh air conditions would do more to exterminate tuberculosis than all the other [illegible] combined, and now that it is [illegible] by the fresh air [illegible] [illegible] in their [illegible].

[1] For details see Scientific American Supplement, Feb. [illegible], 1914.

Arithmetical Machines—II*

Their History, Theory and Methods of Construction

By H. E. Goldberg, M. W. S. E.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2038, Page 60, January 23, 1915

Key-set Machines.—In the class of key-set adding machines are to be found some of the best known machines, such as the Burroughs and Wales. The Burroughs is constructed about as follows: (Figs. 7 and 8.)

There is a bank of keys for each decimal place. Each bank is provided with keys having the values 1, 2, 3, 4, 5, 6, 7, 8, and 9. Co-operating with the keys of each bank is a bar *A*, which has a series of projections upon it, P^1, P^2, P^3, up to P^9. Notice that P^1 is very close to the bottom of the key 1, in fact, just one step removed. P^2 is two steps from the bottom of the key 2; P^9 is nine steps from the bottom of key 9. There is a spring *C* tending to move the gear bar to the left, but it is prevented from so moving by the interference of the cross bar *D*. When the operator depresses a key, he pushes its bottom into the way of the co-operating projection upon the bar. The operator, having thus set up the keys for the number desired, pulls the handle. This advances the bar *D* to the left, thus removing its interference. The bars *A* follow the bar as far as they can, that is, until each bar hits the projection upon the key depressed in its bank Each bar is thus advanced a number of steps corresponding to the value of the key depressed. Some of you have already noticed the fact that if no key is depressed there is nothing to stop the gear bar in its advance. It, therefore, would move the maximum amount, say nine Of course, this must be prevented in an actual machine, and is so prevented by a special stop which prevents the bar *A* from moving, but which stop is pushed out of the way by the pushing down of any key

Totalizer.—You will notice that Fig 8 is drawn to a

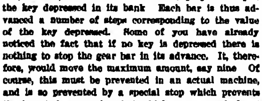


Fig. 8 Fig. 7

larger scale than Fig. 7. This is for the purpose of illustrating the totaliser During the advance of the gear bars, the totaliser wheels *T* were not in mesh with them. After the bars have finished moving leftward, the totaliser is lowered into mesh with the bars When the cross-bar *D* is pushed back, it pushes back the gear bars to their original place, and the meshed totaliser wheels are thus rotated an amount corresponding to the value of the keys set up

Immediately after the rotation of the totaliser wheel by the gear bar, the carrying mechanism operates. The tens-carrying mechanism is constructed somewhat as follows:

Imagine the totaliser wheels *T* mounted on an axle and each wheel provided with a carrying projection *TP*. Between each two wheels is a lever *E* mounted, let us say, friction-tight upon its fulcrum, and having a tooth *F* in the pathway of the pin *TP* The wheel *T* rotates in the direction of the arrow, and in due time its pin *TP* will strike *F* and push away the lever *E* This striking and pushing away of the lever is due notice that the wheel has completed a cycle of motion; that is, arithmetically, it should carry a ten into the next higher wheel to the left. Any wheel that should tens-carry will, therefore, have pushed away its lever. Any wheel that should not tens-carry will not have pushed away its lever. The wheels *T* are rotated by the racks *H* upon the bar *A*, which racks *H* in their turn are pulled by springs *I* fastened both to the racks and to the bar *A*. Each rack *H* is provided with a hook *J* that strikes against the end of the lever *E* whenever that lever is in its approached position: that is, as long as the lever has not been pushed away by the wheel. But when the lever has been pushed away by the wheel, the hook *J* no longer strikes the lever *E*. Instead, it enters below the lever, and thus moves one step further to the right than it would have moved if it had struck the lever.

Notice that each rack *H* is stopped by the lever *E* which is at its right, which lever in turn is moved by the totaliser wheel *T* at its right. That is, finally, the striking of pin *TP* of a wheel against its lever determines that the wheel next to the left shall receive not only the movement which it would otherwise receive, but also an additional step of movement, that is, the tens have been carried into it

The above mechanism is almost identical with that used in the Burroughs and the Dalton machines. Variations are found in the Moon Hopkins and many others The mechanism as described is irreversible, that is,

Ex 1	Ex. 2
9999	9999
1	9999
999'0	'8'8'8'8
99'0'0	'8'8'98
9'0'0'0	'8'998
1'0'0'0'0	1'9998
10000	19998

Fig 9

it will not work if the wheels *T* rotate in the opposite direction The wheels would be stuck when the pin *TP* would strike *F* This sticking of the wheel at this point when rotating in the opposite direction is used in the above machines in bringing said wheels to the zero position, as in erasing a number on a totaliser or in the printing of a total The tens-carrying of this mechanism is, of course, successive The wheel to the left does not carry until the wheel to the right has done so, but it is very rapid, and in practice but little time is occupied thereby

A totaliser like the above that accumulates simultaneously, but that carries successively, would digest the examples previously used in the following manner (Fig. 9)

Having already in its stomach the first number, 9999, it swallows the second number as a whole, but does not assimilate it immediately. The result as to the first bite would be ('8), ('8), ('8), ('8). The little (') shows that it is a number temporarily stored up to be afterward carried Mechanically it means that the lever next to the wheel has been pushed away. A series of digestive steps now occur, which successively transform the contents into the number desired. The first digestive step results in the carrying of the units (') into the tens, thus giving ('8), ('8), ('9), 8 That is, the tens rack has moved an extra step. The second digestive step produces ('8), ('9), 98. That is, the hundreds racks has moved an extra step The third step shows ('9), 998. And the last step produces 19998

The totalisers of many machines operate on this principle of delayed seriatim carrying

Any machine whose totaliser would accumulate and carry simultaneously would make but one bite of the whole meal. Thus 9900 and 9999 is 19998. There are no machines on the market whose totalisers operate on that principle, but there are quite a number described among the patents issued in the United States. Let me state here that one mechanical basis for the possibility of accomplishing all the accumulations and all the carryings simultaneously rests on the employment of trains of epicyclic gears.

Ten-key Machines—Let us go a little further into the theory of the ten-key machines. We noted that

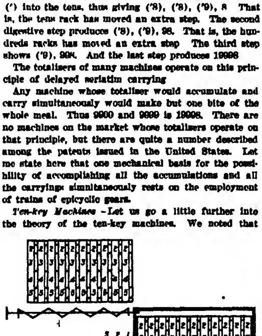


Fig. 10

every totaliser has a set of totaliser wheels, one for units, one for tens, another for hundreds, etc. When on a typewriter a number is printed in a column, as in arranging dollars and cents properly, it is the business of the operator to bring the carriage of the machine to the proper place for the first figure, and from then on they follow in proper order This readily solves the problem for all typewriter attachments such as the Wahl and the Elliott-Fisher On some machines, however, as the Dalton and the Moon-Hopkins, there is no carriage which is first decimally placed by the operator When on such a ten key machine an operator strikes a 1, how does the machine know that it is a 1? Perhaps it is only the first figure of a number, say 127. Historically, the accomplishing of the result was found difficult, as is shown by the fact that in the earlier machines the inventors put down the figures backward Thus 127 used to be put down, first 7, then 2, then 1. The first men to show mechanisms which permitted the figures to be written down highest figure first, units last, were Mr McCaskey and Mr. Helmick, both now of Chicago. The idea occurred to each of them independently, and as they both applied for patents in 1894 some complications arose as to who was the inventor. The means by which they accomplished the result was the introduction of a supplementary carriage capable of storing up a number. (Fig 10)

Let there be a series of windows through which numbers become exposed to the operator of a machine. Let W^1 be the units place window, W^2 the tens place, etc Let *A* be a carriage something like the carriage of a typewriter, and provided in a similar manner with

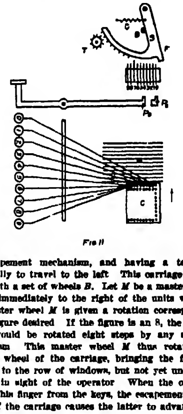


Fig 11

an escapement mechanism, and having a tendency continually to travel to the left This carriage is provided with a set of wheels *B*. Let *M* be a master wheel located immediately to the right of the units window. The master wheel *M* is given a rotation corresponding to the figure desired If the figure is an 8, the master wheel would be rotated eight steps by any suitable mechanism This master wheel *M* thus rotates the leftmost wheel of the carriage, bringing the figure 8 opposite to the row of windows, but not yet under the window in sight of the operator When the operator releases his finger from the keys, the escapement mechanism of the carriage causes the latter to advance one step to the left. The 8, therefore, comes into view in the units window The moving of the carriage has thus brought opposite to the master wheel the next wheel to the right. The pushing down of another key, say 7, by the operator, causes the master wheel *M* to introduce a 7 into this second wheel, and the subsequent escapement and moving of the carriage another step to the left brings this 7 into view in the units window, moving the original 8 into the second window, the whole number now visible being 87 And so on A set of totaliser wheels *T* is located in alignment with the windows, and the carriage with its wheels is, therefore, brought into alignment not only with the windows, but also with the totaliser wheels Further operation depends upon the construction of the machine But in every ten key machine where it is not the operator that first determines what decimal place is to be operated in a traveling carriage is provided for storing up the numbers, which carriage travels toward the left In Fig 10 the traveling carriage is represented as provided with a set of wheels which are rotated by a master wheel.

Fig. 11 represent the construction of the Moon Hopkins

* A paper read before the Western Society of Engineers and published in the Journal of the Society.

kins and the Dalton machines—more particularly the Dalton. There are ten keys, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, which are fulcrumed upon an axis. The back ends of the keys are bent together to form a line, and end in a series of projections, P^1, P^2, P^3, etc. Pushing down the finger piece at the front of the key pushes up the corresponding projection upon the back of the key. Traveling immediately above the projections at the backs of the key levers is a carriage C provided with decimal banks of stops, each stop, say, friction-tight in its bearings. The carriage is provided with an escapement mechanism like that of a typewriter. It can thus be seen that when an operator presses, say, key 7, the pin corresponding to 7 will be pushed up as shown in Fig. 11, and the carriage will advance one step to the left, bringing a new bank of stops over the projections that are at the backs of the keys. The keys can then operate upon the next bank of stops, and the number is thus set up upon the carriage.

After the number has been set up upon the stops in the carriage, it is transferred to the totalizer by means of some large sectors S, each of which is provided with a finger F capable of striking the stop opposite to it in the carriage. Normally, the sectors are held back by means of a bar B against the force of the springs G; but when the bar is moved, as is done during the pulling of the handle, its resistance is removed, and the sectors advance as far as they can, that is, until they are stopped by the protruded pins in the carriage. In the Moon-Hopkins machine, racks instead of sectors are used; otherwise the mechanism is about the same. The carrying mechanism in both of these machines, the Moon-Hopkins and the Dalton, is similar in theory to that described in connection with the Burroughs machine.

I have given no space to printing mechanism, which is quite a problem in itself, particularly the non-printing of the zeros at the left of a significant figure. Thus, in a machine which has, say, seven decimal places, the number 1000 would have the three zeros to the right of the 1 printed, whereas there would be no zeros printed at the left of the 1. The printing mechanism varies considerably in the machines on the market. As a general principle, the mechanism for the preventing of the printing of the undesired zeros works by preventing the printing hammers from flying to make an impression.

Multiplying and Dividing Machines.—A multiplying and dividing machine differs from an adding machine in that it must preserve the multiplicand that is set up on the mechanism. All multiplying machines, without exception, preserve the multiplicand during the process of multiplication. In adding machines, the addend is destroyed after the first addition. Figure 12 shows a diagrammatic representation of the mechanism of Grant's arithmetical mill. The machine is supplied with a carriage C capable of being reciprocated by means of a crank D. Mounted in the carriage are a series of racks R, each provided with a handle H, by means of which the operator can advance it in the carriage to any desired position. In the figure, one of the racks only is shown, and it is advanced four steps. Of course, there is a rack for each decimal place, one for units, one for tens, etc. The operator advances each rack the desired amount, and the machine locks these racks into place in the carriage. The rotation of the crank D then advances both carriage and racks toward the totalizer wheels T, which are thus engaged by the racks, and each is rotated an amount dependent upon the distance that its particular rack has previously been advanced. There is, of course, mechanism for preventing the rotation of the wheels T upon the return movement of the carriage and racks, but into that I shall not enter. Notice that by this means the number set up upon the carriage is not disturbed, but can be used over and over.

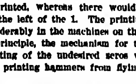


Fig. 12

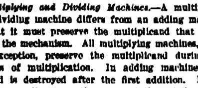


Fig. 13

In Fig. 13 is shown another means that is used in multiplying machines for inserting the number in the totalizer. For each decimal place there is a barrel B, part of which, approximately one-third, is covered with teeth which vary in length from a maximum to a minimum, and have the values 9 to 0. Parallel with the axis of the barrel is a square shaft C, whereon is slidably mounted a gear D, which, by means of a handle H, is slid by the operator opposite any desired point. The rotation of the barrel will, therefore, cause the wheel D to be rotated a number of steps, dependent upon the number of teeth on the barrel B opposite said wheel. That is, it will be rotated only one step when it is opposite the lower end of the long tooth, and nine steps when it is opposite all of the teeth, as at the upper end. The figure to the left shows a development of the surface of the barrel. The reason why the teeth upon the barrel occupy only about one third of the circumference is that the other two thirds is used in the carrying mechanism, which I shall not illustrate at this moment. The above mechanism is the one invented by Leibnitz about 1675 and is now used in the Thomas, the Burkhard, the Tim, the Saxonia, the Archimedes, the Monroe, and many others.

The mechanism in Fig. 14 represents the construc-

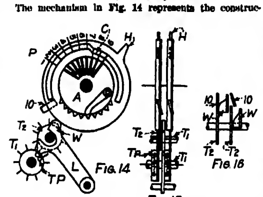


Fig. 14 Fig. 15 Fig. 16

tion of the Brunsviga machine and its brethren, the Thales, the Triumphator, the Marchand, and others. There is a drum A capable of being rotated about its axis, and provided in each decimal place with a mechanism like the one before us. In each decimal place there is a rotatable cam provided with a handle H, by means of which the operator may rotate it about the axis of the drum A. The operator may thus project outside of the circumference of the drum a series of pins P, or retract them into the circumference. In Fig. 14 we see that six pins have been projected, whereas three remain below the surface. Mounted upon axes parallel to that of the drum are two totalizer wheels T^1 and T^2, always in mesh with each other, and each provided with ten teeth. It is evident that a rotation given to the drum about its axis will cause the projected teeth or pins P to pass by the teeth of T^1 and rotate it an amount dependent upon the number of pins set out. Moreover, this will occur at every revolution of the drum.

Should the drum be rotated in the opposite direction, then the wheels T^1 and T^2 will still be rotated an equal amount, but in the opposite direction, thus accomplishing subtraction instead of addition.

The carrying mechanism of the Brunsviga will now be sketched. Upon the wheel T^1 is a pin TP. Co-operating with the pins is a lever L mounted, say, friction-tight upon its fulcrum. It is evident that whenever the pin TP passes by the lever, it will push it away from the wheel T^1 upward toward the drum A. The lever L carries a peculiar wedge-shaped piece W near the drum. Fig. 16 shows a view of the wedge taken on a plane, including the axes of the drum and the two sets of wheels. Mounted on the drum is a special carrying tooth 10. It is normally held to the right by means of a spring, and in passing will not engage the wheel T^2 to the left. In Fig. 16 are shown two adjacent wheels T^2, two wedges W, one to the right and one to the left, and two special carrying teeth 10. The carrying tooth 10 to the right is in its normal position. In passing by the wheel T^2 it would not be interfered with by the wedge W. It would, therefore, miss the wheel T^2. Suppose, however, that previous to the coming around of the carrying tooth 10, the wedge W had been pushed in the way of the tooth 10, as is shown by the wedge to the left, the tooth 10 would now strike the wedge immediately before striking the wheel T^2. It would thus be shoved to the left, and in passing by would engage and turn the wheel T^2 one step. It would thus rotate said wheel a special carrying step.

In order that the carrying steps upon the various wheels of the totalizer shall not interfere with each other, these steps are made successive. One is completed before the other commences. To accomplish this the teeth 10 are placed in a spiral around the drum. The spiral always operates units first, tens next, etc. This may require that there shall be a different spiral for subtraction than for addition, and in the Brunsviga, the Monroe, and other machines this is accomplished by providing two spirals, one of which is effective for addition, and the other one for subtraction.

The above multiplying and dividing machines multiply and divide by repeated addition and subtraction. In multiplying any multiplicand by, say, 7, the multiplicand is rapidly added seven times. Since the highest possible figure is 9 and the lowest is 1, we might say that the average figure is 5, and that these repeated addition multiplying machines require five steps for multiplying by an average figure. There are, however, multiplying machines which do not operate on the repeated-addition principle. They embody in their mechanism a mechanical representation of the multiplication table.

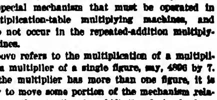
In Fig. 17 is shown the multiplication table as taught to us in school. Please notice that I have filled out each product until it always contains two figures, one in the tens place, another in the units. Immediately below we see a section of this multiplication table taken through 7, and above that are the products represented mechanically by various lengths of pins, the first pin representing the tens place, and the second pin the units place. For instance, $6 \times 7 = 42$ is represented by a pin in the tens place whose length is 4, and another pin in the units place whose length is 2. The scheme indicated, namely, the representation of the multiplication table by different lengths of pins, was the one first proposed as a mechanical representation of the multiplication table, and was brought out by Leon Bollée, a Frenchman, many years ago—I think in 1896. After him there came many others. Kindly notice that in a multiplication-table multiplying machine it is necessary to perform two additions for each decimal place, namely, the addition of the figures in the tens place and the addition of the figures in the units place. This would seem to indicate that the multiplication-table multiplying machine requiring only two additions per decimal place is about two and a half times as fast as the repeated-addition multiplying machines, which require five additions on the average for each decimal place. In practice, however, the difference is considerably reduced by the special mechanism that must be operated in the multiplication-table multiplying machines, and which do not occur in the repeated-addition multiplying machines.

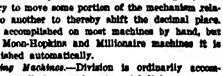
The above refers to the multiplication of a multiplicand by a multiplier of a single figure, say, 4896 by 7. In case the multiplier has more than one figure, it is necessary to move some portion of the mechanism relatively to another to thereby shift the decimal place. This is accomplished on most machines by hand, but on the Moon-Hopkins and Millionaire machines it is accomplished automatically.

Dividing Machines.—Division is ordinarily accomplished mentally by guessing at a trial divisor, attempting the division, seeing whether it is right or wrong, and correcting the result in accordance therewith. This guessing process has not been followed mechanically; in the machines that divide, division is accomplished by continuous subtraction of the divisor and the determination when that divisor has been subtracted a sufficient number of times. In the machines on the market this determination occurs whenever the remainder obtained by the continuous subtraction of the divisor from the dividend becomes negative. That is, it occurs just one step too late. This necessitates one retracing step to correct the error just introduced. The machines, therefore, operate as follows:

Subtract, subtract continually until the remainder becomes negative. This is now one step too far. Therefore, add once to correct this last wrong subtraction and then step down one decimal place, and repeat the process.

In some machines on the market the operator has to watch to see when the remainder will become negative. In others, namely, the Millionaire, the Brunsviga, the





Section Through 7

Fig. 17

Thales, the Marchand, etc., an audible signal is given by ringing a bell whenever the remainder becomes negative.

You will, therefore, notice that only a repeated-addition multiplying machine can be readily used as a dividing machine.

The Birth-Time of the World*

Methods of Determining Its Age

By Prof. J. Joly, Sc.D., F.R.S.

Of the earth's origin we have no certain knowledge; nor can we assign any date to it. Possibly its formation was an event so gradual that the beginning was spread over immense periods. We can only trace the history back to certain events which may with considerable certainty be regarded as ushering in our geological era.

Notwithstanding our limitations the date of the birth-time of our geological era is the most important date in science. For in taking into our minds the spacious history of the universe it must play the part of time-unit upon which all our conceptions depend. If we date the geological history of the earth by thousands of years, as did our forerunners, we must shape our ideas of planetary time accordingly; and the duration of our solar system, and of the heavens, becomes comparable with that of the dynasties of ancient nations. If in millions of years the sun and stars are proportionately venerable. If in hundreds or thousands of millions of years the human mind must consent to correspondingly vast epochs for the duration of material changes. The geological age plays the same part in our views of the duration of the universe as the earth's orbital radius does in our views of the immensity of space.

A study of the rocks shows us that the world was not always what it now is and long has been. We live in an epoch of denudation. The rains and frosts disintegrate the hills; and the rivers roll to the sea the finely divided particles into which they have been resolved; as well as the salts which have been leached from them. The sediments collect near the coasts of the continents; the dissolved matter mingles with the general ocean. The geologist has measured and mapped these deposits and traced them back into the past, layer by layer. He finds them ever the same: sandstone, slates, limestones, etc. But one thing is not the same. *Life* grows ever less diversified in character as the sediments are traced downwards. Mammals and birds, reptiles, amphibians, fishes, die out successively in the past; and barren sediments ultimately succeed, leaving the first beginnings of life undecipherable. Beneath these barren sediments lie rocks collectively differing in character from those above; mainly volcanic or poured out from fissures in the early crust of the earth. Sediments are scarce among these materials.[1]

There can be little doubt that in this underlying floor of igneous and metamorphic rocks we have reached those surface materials of the earth which existed before the long epoch of sedimentation began, and before the seas came into being. They formed the floor of a vaporized ocean upon which the waters condensed here and there from the hot and heavy atmosphere. Such were the probable conditions which preceded the birth-time of the ocean and of our era of life and its evolution.

It is from this epoch we date our geological age. Our next purpose is to consider how long ago, measured in years, that birth-time was.

THE AGE BY THE THICKNESS OF THE SEDIMENTS.

The earliest recognized method of arriving at an estimate of the earth's geological age is based upon the measurement of the collective sediments of geological periods, and consists in measuring the depths of all the successive sedimentary deposits where these are best developed. The total of these measurements would tell us the age of the earth if their tale was indeed complete, and if we knew the average rate at which they have been deposited. Thus it is not easy to measure the real thickness of a deposit. It may be folded back upon itself, and so we may measure it twice over. We may exaggerate its thickness by measuring it not quite straight across the bedding or by unwittingly including volcanic materials. On the other hand, there may be deposits which are inaccessible to us; or, again, an entire absence of deposits; either because not laid down in the areas we examine, or, if laid down, again washed into the sea. These sources of error in part neutralize one another. Some make our resulting age too long, others make it out too short. But we do not know if a balance of error does not still remain. Here, however, is a table of deposits which summarizes a great deal of our knowledge of the thickness of the stratigraphical accumulations. It is due to Prof. Sollas.[2]

	Feet.	
Recent and Pleistocene	4,000	
Pliocene	13,000	
Miocene	14,000	
Oligocene	12,000	
Eocene	20,000	
		63,000
Upper Cretaceous	24,000	
Lower Cretaceous	20,000	
Jurassic	8,000	
Trias	17,000	
		69,000
Permian	12,000	
Carboniferous	29,000	
Devonian	22,000	
		63,000
Silurian	15,000	
Ordovician	17,000	
Cambrian	26,000	
		58,000
Keweenawan } Algonkian	50,000	
Animikian } Algonkian	14,000	
Huronian } Algonkian	18,000	
		82,000
Archæan	?	
Total		335,000 feet

In the next place we require to know the average rate at which these rocks were laid down. This is really the weakest link in the chain. The most diverse results have been arrived at, which space does not permit us to consider. The value required is most difficult to determine, for it is different for the different classes of material, and varies from river to river according to the conditions of discharge to the sea. We may probably take it as between two and six inches in a century.

Now the total depth of the sediments as we see is about 335,000 feet (or 64 miles), and if we take the rate of collecting as 3 inches in a hundred years we get the time for all to collect as 134 millions of years. If the rate be 4 inches, the time is 100 millions of years, which is the figure Geikie favored, although his result was based on somewhat different data. Sollas most recently finds 80 millions of years.[3]

THE AGE BY THE MASS OF THE SEDIMENTS.

In the above method we obtain our result by the measurement of the *linear* dimensions of the sediments. These measurements, as we have seen, are difficult to arrive at. We may, however, proceed by measurements of the *mass* of the sediments, and then the method becomes more definite. The new method is pursued as follows:

The total mass of the sediments formed since denudation began may be ascertained with comparative accuracy by a study of the chemical composition of the waters of the ocean. The salts in the ocean are undoubtedly derived from the rocks, increasing age by age as the latter are degraded from their original character under the action of the weather, etc., and converted to the sedimentary form. By comparing the average chemical composition of these two classes of material—the primary or igneous rocks and the sedimentary—it is easy to arrive at a knowledge of how much of this or that constituent was given to the ocean by each ton of primary rock which was denuded to the sedimentary form. This, however, will not assist us to our object unless the ocean has retained the salts shed into it. It has not generally done so. In the case of every substance but one only, the ocean continually gives up again more or less of the salts supplied to it by the rivers. The one exception is the element sodium. The great solubility of its salts has protected it from abstraction, and it has gone on collecting during geological time, practically in its entirety. This gives us the clue to the denudative history of the earth.[4] It is the secret of the sea.

The process is now simple. We estimate by chemical examination of igneous and sedimentary rocks the amount of sodium which has been supplied to the ocean per ton of sediment produced by denudation. We also calculate the amount of sodium contained in the ocean. We divide the one into the other (stated, of course, in the same units of mass), and the quotient gives us the number of tons of sediment. The most recent estimate of the sediments made in this manner affords 50×10^{16} tonnes.[5]

Now we are assured that all this sediment was transported by the rivers to the sea during geological time. Thus it follows that if we can estimate the average annual rate of the river supply of sediments to the ocean over the past we can calculate the required age. Now the land surface is at present largely covered with the sedimentary rocks themselves. Sediment derived from these rocks must be regarded as, for the most part, purely cyclical; that is, circulating from the sea to the land and back again. It does not go to increase the great body of detrital deposits. We cannot, therefore, take the present river supply of sediment as representing that obtaining over the long past. If the land was all covered still with primary rocks we might do so. It has been estimated that about 25 per cent of the existing continental area is covered with archæan and igneous rocks, the remainder being sediments.[6] On this estimate we may find valuable major and minor limits to the geological age. If we take 25 per cent only of the present river supply of sediment, we evidently fix a major limit to the age, for it is certain that over the past there must have been on the average a faster supply. If we take the entire river supply, on similar reasoning we have what is undoubtedly a minor limit to the age.

The river supply of detrital sediment has not been very extensively investigated, although the quantities involved may be found with comparative ease and accuracy. The following table embodies the results obtained for some of the leading rivers.[7]

	Mean annual discharge in cubic ft. per second	Total annual sediment in thousands of tons.	Ratio of sediment to water by weight.
Potomac	20,160	5,557	1 : 3,575
Mississippi	610,000	406,250	1 : 1,500
Rio Grande	1,700	3,830	1 : 291
Uruguay	150,000	14,782	1 : 10,000
Rhone	65,850	36,000	1 : 1,775
PO	62,200	67,000	1 : 900
Danube	315,200	108,000	1 : 2,880
Nile	113,000	54,000	1 : 2,050
Irrawaddy	475,000	291,430	1 : 1,610
Mean	201,468	109,650	1 : 2,731

We see that the ratio of the weight of water to the weight of transported sediment in six out of the nine rivers does not vary widely. The mean is 2,730 to 1. But this is not the required average. The water-discharge of each river has to be taken into account. If we ascribe to the ratio given for each river the weight proper to the amount of water it discharges, the proportion of weight of water to weight of sediment, for the whole quantity of water involved, comes out as 2,520 to 1.

Now if this proportion holds for all the rivers of the world—which collectively discharge about 27×10^{15} tonnes of water per annum—the river-born detritus is 1.07×10^{13} tonnes. To this an addition of 11 per cent has to be made for silt pushed along the river bed.[8] On these figures the minor limit to the age comes out as 47 millions of years, and the major limit as 188 millions. We are here going on rather deficient estimates, the rivers involved representing only some 6 per cent of the total river supply of water to the ocean. But the result is probably not very far out.

We may arrive at a probable age lying between the major and minor limits. If, first, we take the arithmetic mean of these limits, we get 117 millions of years. Now this is almost certainly excessive, for we here assume that the rate of covering of the primary rocks by sediments was uniform. It would not be so however, for the rate of supply of sediment must have been continually diminishing during geological time, and hence we may take it the rate of advance of the sediments on the primary rocks has also been diminishing. The average rate of supply has therefore been greater than the mean rate. Now we may probably take, as a fair assumption, that the sediment-covered area was at any instant increasing at a rate proportionate to the rate of supply of sediment; that is, to the area of primary rocks then exposed. On this assumption the age is found to be 87 millions of years.

THE AGE BY THE SODIUM OF THE OCEAN.

I have next to lay before you a quite different method. I have already touched upon the chemistry of the ocean, and on the remarkable fact that the sodium contained in it has been preserved, practically, in its entirety from the beginning of geological time.

* Delivered before the Royal Dublin Society, reprinted from Science Progress.

[1] For a discussion of these early rocks, see especially the monograph of Van Hise and Leith on the Pre-Cambrian Geology of North America (Bulletin 360, U. S. Geol. Survey).

[2] Address to the Geol. Soc. of London, 1909.

[3] Geikie, *Text Book of Geology* (Macmillan, 1903), vol. I. p. 73 *et seq.* Sollas, *loc. cit.* Joly, *Radioactivity and Geology* (Constable, 1909), *Phil. Mag.* September, 1911.

[4] *Trans. R.D.S.*, May 1899.

[5] Clarke, *A Preliminary Study of Chemical Denudation* (Washington 1910). My own estimate in 1899 (*loc. cit.*) made as a test of yet another method of finding the age, showed that the sediments may be taken as sufficient to form a layer 1.1 mile deep if spread uniformly over the continents; and would amount to 64×10^{16} tons.

[6] Van Tillo, *Comptes Rendues* (Paris), vol. cxiv. 1892.

[7] Russell, *River Development* (John Murray, 1898).

[8] According to observations made on the Mississippi (Russell, *loc. cit.*)

There is little doubt that the primeval ocean was in the condition of a fresh water lake It can be shown that a primitive and more rapid solution of the original crust of the earth by the slowly cooling ocean would have given rise to relatively small salinity The fact is the quantity of salts in the ocean is enormous We are only now concerned with the sodium but if we could extract all the rock salt (the chloride of sodium) from the ocean we would have enough to cover the entire dry land of the earth to a depth of 400 feet It is this gigantic quantity which is going to enter into our estimate of the earth's age The calculated mass of sodium contained in this rock-salt is 14 130 million million tonnes

If now we can determine the rate at which the rivers supply sodium to the ocean we can determine the age [7] As the result of many thousands of river analyses the total amount of sodium annually discharged to the ocean by all the rivers of the world is found to be probably not far from 175 million tonnes [8] Dividing this into the mass of oceanic sodium we get the age as 80 7 millions of years Certain corrections have to be applied to this figure which result in raising it to a little over 90 millions of years By this method Sollas gets the age as between 80 and 150 millions of years My own result was between 80 and 90 millions of years but I subsequently found that upon certain extreme assumptions a maximum age might be arrived at of 105 millions of years [9] Clarke regards the 80 7 millions of years as certainly a maximum in the light of certain calculations by Becker [10]

The order of magnitude of these results cannot be shaken unless on the assumption that there is something entirely misleading in the existing rate of solvent denudation On the strength of the results of another and entirely different method of approaching the question of the earth's age (which shall be presently referred to) it has been contended that it is too low It is even asserted that it is from nine to fourteen times too low We have then to consider whether such an enormous error can enter into the method The measurements involved cannot be seriously impugned Corrections for possible errors applied to the quantities entering into this method have been considered by various writers My own original corrections have been generally confirmed I think the only point left open for discussion is the principle of uniformitarianism involved in this method and in the methods previously discussed

In order to appreciate the force of the evidence for uniformity in the geological history of the earth it is of course necessary to possess an acquaintance with that history Some of the most eminent geologists among whom Lyle and Geikie [11] may be mentioned have upheld the doctrine of uniformity It must here suffice to dwell upon a few points having special reference to the matter under discussion

The mere extent of the land surface does not within limits affect the question of the rate of denudation This arises from the fact that the rain supply is quite insufficient to denude the whole existing land surface About 30 per cent of it does not in fact drain to the ocean If the continents become invaded by a great transgression of the ocean this rainless area diminishes and the denuded area advances inward without diminution If the ocean recedes from the present strand lines the rainless area advances outward but the rain supply being sensibly constant no change in the river supply of salts is to be expected

Age-long submergence of the entire land or of any very large proportion of what now exists is negatived by the continuous sequence of vast areas of sediment in every geological age from the earliest times Now sediment-receiving areas always are but a small fraction of those exposed areas whence the sediments are supplied [12] Hence in the continuous records of the sediments we have assurance of the continuous exposure of the continents above the ocean surface The doctrine of the permanency of the continents has in its main features been accepted by the most eminent authorities As to the actual amount of land which was exposed during past times to denudative effects no data exist to show it was very different from what is now exposed It has been estimated that the average area of the North American continent over geologic time was about eight-tenths of its existing area [13] Restorations of other continents so far as they have been attempted would not suggest any more serious divergency one way or the other

That climate in the oceans and upon the land was throughout much as it is now the continuous chain of teeming life and the sensitive temperature limits of protoplasmic existence are sufficient evidence [14] The influence at once of climate and of elevation of the land may be appraised at their true value by the ascertained facts of solvent denudation as the following table shows

	Tonnes removed in solution per square mile per annum	Mean elevation Meters
North America	79	700
South America	50	650
Europe	100	300
Asia	84	950
Africa	44	650

In this table the estimated number of tonnes of matter in solution which for every square mile of area the rivers convey to the ocean in one year is given in the first column These results are compiled by Clarke from a very large number of analyses of river waters The second column of the table gives the mean heights as meters above sea level of the several continents in cited by Arrhenius [8]

Of all the denudation results given in the table those relating to North America and to Europe are far the most reliable These show that Europe with a mean altitude of less than half that of North America sheds to the ocean 25 per cent more salts Hence if it is true as has been stated that we now live in a period of exceptionally high continental elevation we must infer that the average supply of salts to the ocean by the rivers of the world is less than over the long past and that therefore our estimate of the age of the earth as already given is excessive

There is however one condition which will operate to unduly diminish our estimate of geologic time and it is a condition which may possibly obtain at the present time If the land is on the whole now sinking relatively to the ocean level the denudation area tends as we have seen to move inwards It will thus encroach upon regions which have not for long periods drained to the ocean On such areas there is an accumulation of soluble salts which the deficient rivers have not been able to carry to the ocean Thus the salt content of certain of the rivers draining to the ocean will be influenced not only by present denudative effects but also by the stored results of past effects Certain rivers appear to reveal this unduly increased salt supply those which flow through comparatively arid areas However the flow-off of such tributaries is relatively small and the final effects on the great rivers apparently unimportant —a result which might have been anticipated when the extremely slow rate of the land movements is taken into account

The difficulty of effecting any reconciliation of the methods already described and that now to be given in creases the interest both of the former and the latter

THE AGE BY RADIOACTIVE TRANSFORMATIONS

Rutherford suggested in 1905 that as helium was continually being evolved at a uniform rate by radioactive substances (in the form of the alpha rays) a determination of the age of minerals containing the radioactive elements might be made by measurements of the amount of the stored helium and of the radioactive elements giving rise to it The parent radioactive substance is —according to present knowledge—uranium or thorium. An estimate of the amounts of these elements present enables the rate of production of the helium to be calculated Rutherford shortly afterwards found by this method an age of 240 millions of years for a radioactive mineral of presumably remote age Strutt who carried his measurements to a wonderful degree of refinement found the following ages for mineral substances originating in different geological ages

Oligocene	8 4	millions of years.
Eocene	31	
Lower Carboniferous	150	
Archæan	710	

Another product of radioactive origin is lead The suggestion that this substance might be made available to determine the age of the earth also originated with Rutherford We are at least assured that this element cannot escape by gaseous diffusion from the minerals. Boltwood's results on the amounts of lead contained in minerals of various ages, taken in conjunction with the amount of uranium or parent substance present, afforded ages rising to 1 640 millions of years for Archæan and 1 200 millions for Algonkian time Becker applying the same method obtained results rising to quite incredible periods from 1 671 to 11 470 millions of years. Becker maintained that original lead rendered the determinations indefinite. The more recent results of Mr A Holmes support the conclusion that original lead may be present and may completely falsify results derived from minerals of low radioactivity in which the derived lead would be small in amount By rejecting such results as appeared to be of this character he arrives at 370 millions of years as the age of the Devonian.

I must now describe a very recent method of estimating the age of the earth There are in certain rock-forming minerals color-changes set up by radioactive effects The minute and curious marks so produced are known as haloes for they surround in ring-like forms minute particles of included substances which contain radioactive elements The particle in the center of the halo contains uranium or thorium and necessarily along with the parent substance the various elements derived from it In the process of transformation giving rise to these several derived substances atoms of helium, projected with great velocity into the surrounding mineral—the alpha rays—occasion the color changes referred to These changes are limited to the distance to which the alpha rays penetrate hence the halo is a spherical volume surrounding the central substance [15]

The time required to form a halo can be found if on the one hand we could ascertain the number of alpha rays ejected in any one year from the nucleus of the halo and on the other if we determine by experiment just how many alpha rays were required to produce the same amount of color alteration as we perceive to extend around the nucleus

The latter estimate is fairly easily and surely made But to know the number of rays leaving the central particle in unit time we require to know the quantity of radioactive material in the nucleus This cannot be directly determined We can only from known results obtained with larger specimens of just such a mineral substance as composes the nucleus guess at the amount of uranium or it may be thorium which may be present

This method has been applied to the uranium haloes of the mica of County Carlow [16] Results for the age of the halo of from 20 to 400 millions of years have been obtained This mica was probably formed in the granite of Leinster in late Silurian or in Devonian times

The higher results are probably the least in error upon the data involved for the assumption made as to the amount of uranium in the nuclei of the haloes was such as to render the higher results the more reliable

This method is of course a radioactive method and similar to the method by helium storage save that it is free of the risk of error by escape of the helium the effects of which are as it were registered at the moment of its production so that its subsequent escape is of no moment

REVIEW OF THE RESULTS

By methods based on the approximate uniformity of denudative effects in the past, a period of the order of 100 millions of years has been obtained as the duration of our geological age and consistently whether we accept for measurement the sediments or the dissolved sodium We can give reasons why these measurements might afford too great an age but we can find absolutely no good reason why they should give one much too low

By the storage of radioactive products ages have been found which, while they vary widely among themselves yet claim to possess accuracy in their superior limits and exceed those derived from denudation from nine to fourteen times.

In this difficulty let us consider the claims of the radioactive method in any of its forms In order to be trustworthy it must be true (1) that the rate of transformation now shown by the parent substance has obtained throughout the entire past and (2) that there were no other radioactive substances, either now or formerly existing except uranium, which gave rise to lead As regards methods based on the production of helium what we have to say will largely apply to it also If some unknown source of these elements exists we, of course on our assumption over-estimate the age.

As regards the first point In ascribing a constant rate of change to the parent substance—which Becker (loc. cit.) describes as a simple though tremendous extrapolation —we reason upon analogy with the constant rate of decay observed in the derived radioactive bodies. If uranium and thorium are really primary elements,

[7] Trans R D S 1899 A paper by Edmund Halley the astronomer in the Philosophical Transactions of the Royal Society for 1715 contains a suggestion for finding the age of the world on somewhat similar lines He proposes to make observations on the saltness of the seas and ocean at intervals of one or more centuries and from the increment of saltness arrive at their age The measurements as a matter of fact are impracticable The salinity would only gain (if all remained in solution) one millionth part in 100 years and of course the continuous rejection of salts by the ocean would invalidate the method The last objection also invalidates the calculation by T Mellard Reade (Proc Liverpool Geol Soc 1876) of a minor limit to the age by the calcium sulphate in the ocean Both papers were quite unknown to me when working out my method Halley's paper was I think only brought to light in 1908

[8] J W Clarke A Preliminary Study of Chemical Denudation (Smithsonian Miscellaneous Collections 1910)

[9] Loc cit

[10] The Circulation of Salt and Geological Time (Geol Mag 1901 p 350)

[11] Becker (loc cit) assuming that the exposed igneous and archæan rocks alone are responsible for the supply of sodium to the ocean arrives at 74 millions of years as the geological age This matter was discussed by me formerly Trans R D S 1899 pp 54 et seq) The assumption made is I believe quite inadmissible It is not supported by river analyses or by the chemical character of residual soils from sedimentary rocks There may be some convergence in the rate of solvent denudation but—as I think on the evidence—in our time unimportant.

[12] See especially Geikie's Address to Sect. C Brit. Assoc. Rep. 1899.

[13] On the strength of the Mississippi measurements about 1 to 13 (Magee Am Jour of Sc. 1893 p. 189)

[14] C Schuchert, Bull. Geol. Soc. Am. vol. xx. 1910.

[15] See also Poulton. Address to Sect. D Brit. Assoc. Rep. 1896.

[16] Lehrbuch der Kosmischen Physik, vol. i. p. 367

[17] Phil. Mag., March, 1907 and February 1910; also Nature, January, 1913.

[18] Joly and Rutherford, Phil. Mag., April 1913.

however, the analogy relied on may be misleading at least, it is obviously incomplete It is incomplete in a particular which may be very important the mode of origin of these parent bodies—whatever it may have been—is different to that of the secondary elements with which we compare them A convergence in their rate of transformation is not impossible or even improbable so far as we know

As regards the second point It is assumed that uranium alone of the elements in radioactive minerals is ultimately transformed to lead by radioactive changes We must consider this assumption.

Recent advances in the chemistry of the radioactive elements have brought out evidence that all three lines of radioactive descent known to us—i e those beginning with uranium, with thorium and with actinium—alike converge to lead [a] There are difficulties in the way of believing that all the lead-like atoms so produced ("isotopes" of lead, as Mr Soddy proposes to call them) actually remain as stable lead in the minerals For one thing there is sometimes along with very large amounts of thorium an almost entire absence of lead in thorianites and thorites And in some urano-thorites the lead may be noticed to follow the uranium in approximate proportionality notwithstanding the presence of large amounts of thorium [b] This favors the assumption that all the lead present is derived from the uranium The actinium is present in negligibly small amounts

[a] See Soddy's *Chemistry of the Radioactive Elements* (Longmans Green & Co)

[b] It seems very difficult at present to suggest an end product for thorium unless we assume that by loss of electrons thorium E or thorium-lead reverts to a substance chemically identical with thorium itself Such a change—whether considered from the point of view of the periodic law or of the radioactive theory—would involve many interesting consequences It is of course quite possible that the nature of the conditions attending the deposition of the uranium ores many of which are comparatively recent are responsible for the difficulties observed The thorium and uranium ores are, again specially prone to alteration

On the other hand there is evidence arising from the atomic weight of lead which seems to involve some other parent than uranium Mr Soddy in the work referred to points this out The atomic weight of radium is well known and uranium in its descent has to change to this element The loss of mass between radium and uranium-derived lead can be accurately estimated by the number of alpha rays given off From this we get the atomic weight of uranium-derived lead as closely 206 Now the best determinations of the atomic weight of normal lead assign to this element an atomic weight of closely 207 By a somewhat similar calculation it is deduced that thorium-derived lead would possess the atomic weight of 208 Thus normal lead might be an admixture of uranium and thorium-derived lead However as we have seen the view that thorium gives rise to stable lead is beset with some difficulties

If we are going upon reliable facts and figures we must then assume (*a*) That some other element than uranium and genetically connected with it (probably as parent substance) gives rise or formerly gave rise to lead of heavier atomic weight than normal lead It may be observed respecting this theory that there is some support for the view that a parent substance both to uranium and thorium has existed or possibly exists The evidence is found in the proportionality frequently observed between the amounts of thorium and uranium in the primary rocks [c] Or (*b*) We may meet the difficulties in a simpler way which may be stated as follows If we assume that all lead is derived from uranium and at the same time recognise that lead is not perfectly homogeneous in atomic weight we must of necessity ascribe to uranium a similar want of homogeneity heavy atoms of uranium giving rise to heavy atoms of lead and light atoms of uranium generating light atoms of lead This assumption seems to be involved in the figures upon which we are going Still relying on these figures we find however that existing uranium cannot give rise to lead of normal atomic weight We can only conclude that the heavier atoms of uranium have decayed more rapidly than the lighter ones In this connection it is of interest to note the complexity of uranium as recently established by Geiger although in this case it is assumed that the shorter lived isotope is genetically connected with the longer-lived and largely preponderating constituent There does not seem to be any direct proof of this as yet however

[c] Compare results for the thorium content of such rocks (appearing in a paper by the author *Cong Int de Radiologie et d Electricité* vol 1 1910 p 373) and those for the radium content as collected in *Phil Mag* October 1913 p 697

From these considerations it would seem that unless the atomic weight of lead in uraninites etc is subnormal the former complexity and more accelerated decay of uranium are involved in the data respecting the atomic weights of radium and lead and the radioactive events which occur in the transmutation of the one into the other As an alternative view we may assume as in our first hypothesis that some elementally different but genetically connected substance decaying along branching lines of descent at a rate sufficient to practically remove the whole of it during geological time formerly existed Whichever hypothesis we adopt we are confronted by probabilities which invalidate time-measurements based on the lead and helium ratio in minerals We have in short grave reason to question the measure of uniformitarianism postulated in finding the age by any of the known at present radioactive methods

That we have much to learn respecting our assumptions whether we pursue the geological or the radioactive methods of approaching the age of our era is indeed probable Whatever the issue it is certain that the reconciling facts will leave us with much more light than we at present possess either as respects the earth's history or the history of the radioactive elements

Sea-Salt and Geologic Time*

A Discussion of Prof. Joly's Method of Determining the Age of the World

By H S Shelton, B Sc

THE present short article is a reversion to an aspect of the subject of geologic time which I had thought to be settled and to require no further research or controversy In my review of Mr Holmes's book I commented strongly on his ignorance of current literature I now find that the same imperfect acquaintance with recent discussion and research is shared by the writer who is responsible for putting forward the amount of sodium in the sea as an index of geologic time I assume of course that ignorance is the explanation for I take it that no man of science of recognized position when the errors of his research had been pointed out would deliberately ignore the fact and proceed as if his work was a valid contribution to the advancement of science My excuse, therefore for writing an article containing nothing material which I have not previously published is the following passage for which Sir Ernest Rutherford and Prof Joly are jointly responsible

But it is certain that if the higher values so found are reliable the discrepancy with estimates of the age of the ocean based on the now well-ascertained facts of solent denudation raises difficulties which at present seem inexplicable [3]

The values of geologic time referred to based on radioactive methods especially the age of pleochroic haloes, I propose to criticise on a future occasion There are good grounds which cannot be stated here for thinking that all attempts to assess exact times for particular geologic epochs by calculation either of the lead ratios of uranium minerals or otherwise are premature, and are based on an imperfect realization of the complexity of the subject The object of the present article, however, is to repeat[4] the arguments which show that the alternative method based on the salt-content of the ocean is of no value whatever Not only is the discrepancy not inexplicable, there is no discrepancy to explain. So much did I take this for granted that, in my last article on the subject [5] I did not think it necessary to consider the sea-salt method. I therefore take this opportunity to repeat the arguments, and to remedy what is apparently a deficiency

Prof. Joly's original paper[6] was based on the supposed facts (1) that as roughly estimated by Sir John Murray of the solid matter dissolved in river water which reaches the sea 3 47 per cent is sodium (2) that nearly all this hypothetical sodium is obtained by erosion of the rocks (3) that when this hypothetical sodium reaches the sea none of it returns to the rocks On this supposition dividing the amount of sodium in the sea by the amount which reaches it each year an estimate of geologic time could be made The objection is briefly that the three supposed facts are merely supposed facts No single one of them is reliable

For convenience we will take the second point first Of the sodium which actually reaches the sea a considerable proportion is associated with chlorine None of the sodium chloride in the rivers can be attributed to erosion This is so for two reasons In the first place it is well known that the proportion of chlorine in the rocks igneous or sedimentary is infinitesimal In the second place the sources of the chlorine have been thoroughly well determined In the main they are two cyclic salt carried by the wind from the sea and salt due to human contamination It has been found possible particularly in New York State to eliminate the cyclic salt the amount of which is a function of the distance from the coast and to show that the residual chlorine in river water is a direct function of density of population Unless you take the sewage from town and country districts directly out to sea the salt in it inevitably reaches the rivers If you obtain an abnormally high chlorine ratio when the sewage is supposed to be carried out to sea the inference is leakage The source which would naturally occur to any one brine-springs has been shown to be negligible Even in New York State where brine-springs are plentiful there is no appreciable effect on the salt content of the rivers [1] The only known means by which fresh chlorine reaches the sea is volcanic action and it is a point open to dispute how much of the volcanic chlorine is not ultimately derived from the sea. It follows therefore that of the sodium which actually reaches the sea only that not associated with the chlorine can be counted

This much Prof Joly and those who agree with his earlier estimate have been willing to admit But Prof Joly maintains that if the chlorine equivalent of the sodium be substracted there is still sufficient sodium to necessitate an estimate of geologic time less than 150 millions of years. His reason is merely Sir John Murray's rough tabulation of then current analyses and some more recent results It does seem strange however that Prof Joly never troubled to inquire whether there were any water analyses sufficiently accurate for this purpose It is highly probable that Prof Joly's original paper would never have been written if he had understood why water analyses are undertaken and the manner in which they are actually performed Had he been a water analyst or even a chemist the first thing that would have occurred to him would have been that these sodium determinations were decidedly hypothetical Several chemists have expressed doubts as to the validity but such discussions Prof Joly has either ignored or failed to understand [2] It may therefore surprise Prof Joly to be informed that it is doubtful whether the sodium content of any single river water has ever been accurately determined If any such cases have occurred, they are very few Let us imagine that there is in a given sample of river water two parts of sodium per million. Such a proportion would be quite ordinary according to the usual tables It would be a very interesting problem to try to separate this out and weigh it To obtain a good weighable quantity (say 0 05 gram of sodium giving about 0 15 gram of sodium sulphate[3]) would require 25 liters of water the greater part of a carboy and the difficulties in the way of isolating it are such as any chemist can understand

As a matter of fact the accurate determination of the sodium is a form of amusement in which the ordinary water analysts do not indulge Sometimes the alkalis sodium and potassium are determined together by difference that is not determined at all In a paper[4] that has been sent to me recently the analyst describes his methods In this case everything possible is got rid of by the usual methods of precipitation and the remainder is evaporated and weighed as Sodium and Potassium Chlorides The amount dealt with is only that from 250 cubic centimeters of filtered water and would of course be infinitesimal and the fact that it amounts to not more than 2 or 3 per cent of the total dissolved solid is a good indication of the general ac-

* Reprinted from *Science Progress*
[2] *Science Progress*, July 1913.
[3] *Philosophical Magazine*, May 1913, p. 657
[4] [illegible] *Journal of Geology* February [illegible] February 1911
[5] *Science Progress*, October 1912.
[6] [illegible] Sir John Murray [illegible] No. [illegible]

[1] For further information on these points see Jackson's Normal Distribution of Chlorine, U S A. Geological Survey Water Supply Paper No. 144.

[2] See particularly discussion with Mr Acroyd, *Chemical News* 1901 and F W Clarke *Data of Geochemistry* p 110

[3] In ordinary accurate analysis sodium is usually weighed as sulphate In water analysis however the quantity is so small that conversions to sulphate is not worth while The residue is reckoned as chloride though it need not necessarily be so

[4] The Quality of the Surface Waters of Illinois U S A Geological Survey Water Supply Paper No 239, p 18 The method is the one usually recommended in the text-books See Wanklyn, 11th edition, p. 138.

curacy of the analysis. The residue includes of course everything that is not caught by the filter throughout the whole operation. It should be mentioned also that the samples usually stand for days in glass bottles. In such cases of water analysis when the sodium and the potassium are separated the separation is needless to say, a very approximate operation.[14]

It is no reflection on the accuracy of river water analysts to say that the results are of no value whatever for Prof. Joly's purpose. No one except Prof. Joly and a few geologists wants to know the proportion of sodium in river water. It is at the same time the constituent least important for the purpose of the water analyst and the constituent most difficult to determine. The assumption on which Prof. Joly proceeds that 3.47 per cent of the dissolved matter in river water is sodium is absolutely unproven. For all the analyses prove it might be less than half that amount. Indeed the principal evidence that there is an excess of sodium over and above its equivalent of chlorine is indirect rather than direct. The results of rock analyses are more reliable and it seems to be established that the sodium content of igneous rocks is greater than that of the aqueous. As a matter of fact it has been pointed out by Prof. Dubois that when there is any reason to ascribe special accuracy to river water analysis the excess of sodium diminishes and tends to vanish. Prof. Dubois collected a number of good analyses, tabulated them and inferred from them according to Prof. Joly's method a geologic time of 400 million years. The inference he made as he was a believer in Lord Kelvin's methods was that the original sea was salt. The true inference is that the method is of no value. Within the limits of experimental error you can deduce any value you please.

Though the previous discussion renders it unnecessary it is as well to mention one other point. The assumption that no sodium returns from the sea to the rocks is unwarranted. Indeed one instance to the contrary can be mentioned. It is a recognized fact that much of the salt in the salt lakes and inferentially in salt beds is windborne and has its origin in the sea. But what would occur when strata containing salt beds are subject to metamorphosis or are absorbed by the magma? Is it not obvious that the sodium would be added to the content of the rocks and that the chlorine would be expelled as some volatile compound? Indeed is it not probable that some portion of volcanic chlorine has this origin? Again with regard to the ordinary processes of the formation of sedimentary rock we do not know enough to say that no dissolved sodium is reabsorbed.

This speculation however is a side issue and is not necessary to the argument. Were the analyses of sufficient accuracy were the method in general valid such matters would require careful consideration. At present without taking such remote speculations into account we can still say that the sea-salt method is absolutely worthless. It is based on a misapprehension of the data on which it rests. It is an instance of the care that is required when results are transferred from one branch of science to another. With regard to geologic time the value of radioactive methods is still to be determined. The value of the sea-salt method like the still more famous ones of Kelvin and Tait is nil.

The Optical Anisotropy of Liquid Crystals*

By R. O. Lehman

The underlying purpose of all my work has been the proof of the untenability of the "Theory of Identity" of the molecule in all forms of a given substance and the discovery of liquid crystals has furnished the direct proof sought.

I. The untenability of the Theory of Identity.

(a) Transformation temperatures. Molten ammonium nitrate crystallizes at 161 degrees in very soft, regular crystals; at 125.6 degrees these again crystallize into harder tetragonal forms, and so at 82.80 degrees 32.4 degrees and −16 degrees firmer and firmer forms appear. Contrary to the Theory of Identity I found on reheating that the melting points were identical with and not higher than these solidification points from which I conclude that polymorphous transformation is a chemical process entailing alteration of the molecule and from this follows the second conclusion that melting and vaporization change the molecule otherwise two different modifications would furnish two different vapors and liquids.

(b) The plasticity of crystals. According to the Theory of Identity there could be no flowing or true plasticity of crystals nothing but a translation of crystal fragments. My work with ammonium nitrate proved that there do exist plastic crystals, i. e. crystals whose fragments are no larger than single molecules. In the case of silver iodide, above 146 degrees no limit of elasticity could be demonstrated, and the "snapping" of the molecules into definite orderly arrangement was very doubtful.

(c) The solubility of distorted crystals. If variation in solubility of polymorphous forms is due purely to molecular arrangement, as the Theory of Identity presupposes then plastic distortion of crystals (i. e. a disturbance of the molecular arrangement) should alter the solubility. This is not found to be the case.

Although thoroughly convinced that the Theory of Identity was false, and that the soft regular crystals of ammonium nitrate and silver iodide were truly liquid still I was not able to give actual proof that they possessed no limit of elasticity.

II. Reinitzer's isotropic liquid with oily streaks.

After prolonged research I recognized that Reinitzer's isotropic liquid in which crystals and oily streaks are present is different from the isotropic molten mass, and that in all probability it is an entirely irregularly arranged aggregate of the same molecules of which the crystals and oil streaks consist. This conclusion is another contradiction of the Theory of Identity.

III. The first liquid crystals.

Absolute proof of the existence of liquid crystals I first obtained with ammonium oleate hydrate. The polyhedric form of the tiny crystals can be explained only by a more or less disturbed molecular arrangement, and the phenomena of spontaneous homeotropy (the immediate automatic restoration of structure after distortion division or fusion of the crystal units) entirely excludes from the realm of possibility the existence of a limit of elasticity. No further proof can be asked for the existence of liquid crystals.

IV. Classification of crystalline liquids.

From my standpoint the anisotropy of the molecules and not their order of arrangement is the prime factor in determining the classification of a crystalline substance hence I classify liquid and solid crystals exactly alike according to their optical properties. (1) Monosymmetrical (2) asymmetrical (3) regular (4) tetragonal and hexagonal (5) rhombic etc.

The Sense of Smell in Insects

The Smithsonian Institution has recently issued a paper by Dr. N. E. McIndoo dealing with the olfactory sense of insects which consists of a general review of this unusually confused subject presenting the views of different authors discussing the seat of the olfactory organs summarizing the author's experiments and citing a large number of scientific treatises on the subject which constitutes the first classification of such literature.

From the views of very early writers including Aristotle, Virgil, Pliny and others it is evident that the belief in a sense of smell in insects has long been known and believed generally; also that some insects are able to distinguish various odors. While it is seldom denied that insects can smell no one has yet ascertained the relative sensitiveness for any particular species nor is the seat of the organs definitely located for all species.

The writings discussed are classified according to their viewpoints as to the seat of the olfactory organs which seems to be the main point of disagreement among them. One theory which has long since been abandoned was that these organs were located in the spiracles or nostrils of the insects as in the case with the higher animals but it was advocated by assumption rather than experiment as no one has found any nerves or organs which suggest an olfactory function either in the spiracles or in the tracheae the windpipe.

One author holds that these organs are located in the throats of the various insects; one in the mouth cavity; several in the feelers attached to the mouth; many in the antennae; and so on until nearly every available portion of the insect's anatomy has been suggested by one or another student. Dr. McIndoo however has proved by experiments that many of these theories are wrong by covering up removing or otherwise eliminating various organs and testing the smell of bees ants and hornets thus treated nearly all of which respond as readily and as quickly to the fraction of a second as normal bees ants and hornets under similar conditions.

About one half of his experiments were conducted to disprove the somewhat general belief that the sense of smell of insects is located in the antennae, the horns or feelers attached to the head constituting the organs of touch. To this end the experimenter tested honey bees, ants and hornets by removing one or both of their antennae and noting the results when the insects were subjected to the odors from the essential oils of peppermint, thyme, and wintergreen. Honey, pollen, pennyroyal, formic acid from ants, etc., were also used in testing the sense of smell.

After disproving the theories of all the other writers concerning the seat of the olfactory organs, the author began to search for organs similar to those which he found a few years ago in spiders. These organs were soon found on the legs and wings of all the insects examined. Many experiments were performed which proved conclusively to the author that these organs are the true apparatus for receiving odor stimuli in the insects tested.

It is certain that spiders can smell, yet they have no antennae nor any organs that may be compared to the antennal organs of insects. This is another argument against the antennae being organs of smell. All insects either have antennal organs like those of the bees, or modifications of them; yet no two authors who have studied them have agreed concerning their function. Such chaos can be replaced by facts only when the behavior of the insects investigated is thoroughly studied and when experiments are performed in ways other than on the antennae alone. Then it will be realized that the antennae can no longer be regarded as a possible seat of the sense of smell in insects.

In conclusion it seems that the organs called the olfactory pores by the author are the true olfactory apparatus in bees, ants and hornets and possibly in all insects and that the antennae play no part in receiving odor stimuli.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JANUARY 30, 1915

Published weekly by Munn & Company Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year	$5.00
Scientific American (established 1845)	3.00
American Homes and Gardens	3.00

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Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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[14] The potassium determination would be the more accurate of the two as the potassium is weighed as $Pt + 2KCl$. A further percentage of inaccuracy would thus be thrown on the sodium.

Proceedings Amsterdam Academy 1904

* Translated from *Physikalische Zeitschrift* for the Scientific American Supplement.

SCIENTIFIC AMERICAN SUPPLEMENT

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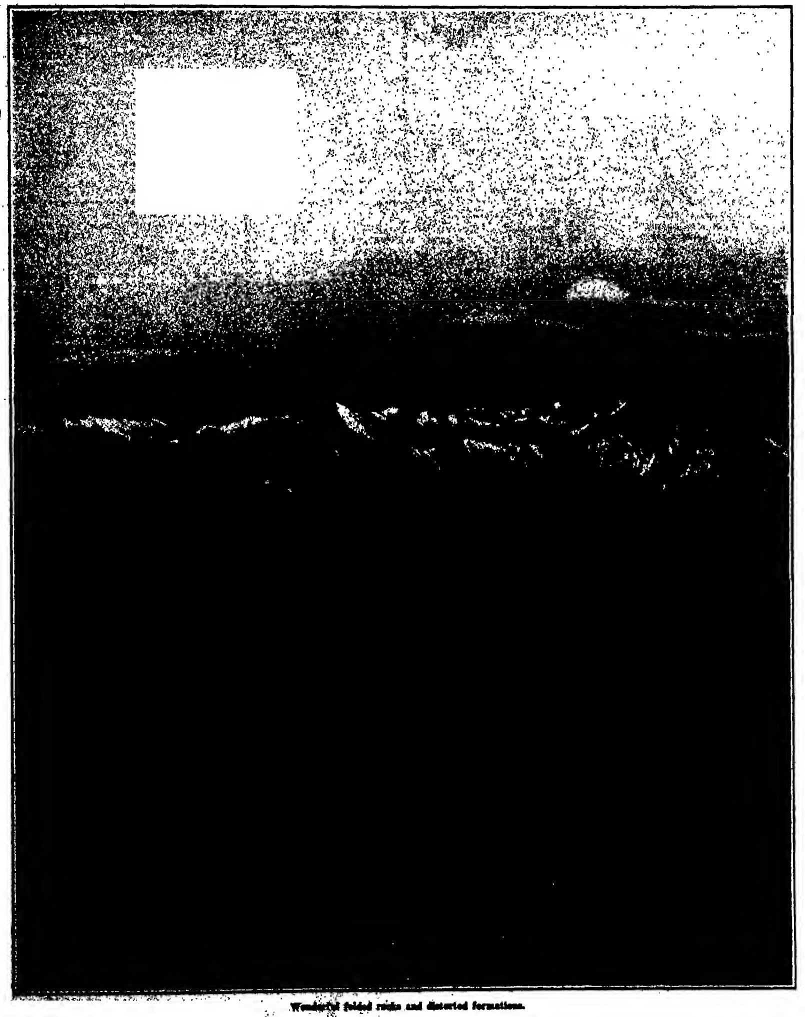
VOLUME LXXIX] NUMBER 2040] NEW YORK, FEBRUARY 6, 1915 [10 CENTS A COPY $5.00 A YEAR



Wonderful folded rocks and distorted formations.

THE ORIGIN OF THE ROCKY MOUNTAINS.—[See page 83.]

Recent Significant Developments in Science and Engineering*

A Review and Explanation of the Most Important Advances

The following brief notes describe what seem to be the most significant developments in several of the sciences and branches of engineering. The subjects selected and the material used in the description are due to various professors in Cornell University all of whom are authorities in the several fields touched upon.

PHYSICS

X Rays and Crystalline Structure—One of the most interesting developments in modern physics is the recent discovery that Roentgen rays can be reflected and diffracted by means of crystals. As an immediate result of this discovery not only has the true nature of X rays themselves been learned but scientists have been able to explore the inner structure of crystals, learning the arrangement of and measuring the distance between the atoms of which they are built. It even seems as though we may be able to probe still deeper by this means, and to find out how the atoms themselves are made.

From the large amount of experimental evidence obtained in the last two years we have every reason to believe that X rays are electromagnetic waves of extremely short wave length about ten thousand times smaller than those of ordinary visible radiation. To measure these wave-lengths in the usual manner by means of a ruled diffraction grating was therefore out of the question. It occurred to Laue that in the regular arrangement of atoms in a crystal we have gratings whose lines are naturally ruled so closely that their distances are of the same order of magnitude as the wave-lengths of X rays. Messrs Friedrich and Knipping tried the experiment of passing a fine beam of X rays through a crystal of zinc blende a short distance behind which was placed a photographic plate. Upon developing the negative they found a remarkable group of spots arranged symmetrically about the central image.

But within the past year still more interesting results have been obtained by Prof W H Bragg and his son W L Bragg[1] who have used this method to determine the structure of crystals. Mr W L Bragg explained each spot on the photographs as being due to the regular reflection of the beam of X rays from a plane in the crystal which is especially rich in atoms. Thus for instance if the atoms are arranged in the form of a cubical lattice work the rays would be partially reflected from planes which contain a relatively large number of atoms.

The cleavage face of a crystal is very rich in atoms so to test his explanation Mr Bragg allowed a beam of X rays to fall on a cleavage face of a crystal and found as he had predicted that an image was produced on the photographic plate at the angle of reflection. But he noticed that as the angle of incidence was changed there were certain angles at which the reflection was exceptionally strong. These positions of strong reflection could be explained in only one way as real spectrum lines in the X rays-radiation of definite wave length. This explanation led at once to a definite knowledge of the nature of X rays.

When an X ray pulse strikes the cleavage face of a crystal at a definite angle a part of it is reflected by each layer of atoms. If the angle is of the proper value as determined by the wave length of the train of waves and by the distance between the layers of atoms then the reflected pulses will reinforce each other and produce an especially strong image. This was studied by means of an apparatus in which the intensity of a reflected beam could be made to act on an electroscope whose deflection was measured by microscope.

At this time no one knew whether it was the molecules or the individual atoms which did the reflecting. Whatever the reflecting centers were however there was now a means of finding out how they were arranged in the crystal. Mr Bragg imagined a number of different arrangements of these centers, and on the theory that each spot in Friedrich and Knipping's photographs was a partial reflection of the primary beam by some plane rich in atoms he calculated where the spots should be found for each arrangement. It was found that nothing but a simple cubical design could account satisfactorily for the spots obtained with such crystals as salt, potassium chloride etc. Thus we find that in a crystal of rock salt the sodium and chlorine atoms are arranged in the form of a cubical lattice work with chlorine and sodium atoms situated in alternate corners of the cubes so that for example the sodium atom has six neighboring chlorine atoms equally close with which it might pair off to form a molecule of NaCl. It was calculated that with this arrangement the distance between atoms was a trifle over one hundredth millionth of an inch. It is interesting to note that in this arrangement there is no evidence that the atoms are combined into molecules. A sodium atom is no more closely connected with one particular chlorine atom than with any other.

In much the same way Prof W H Bragg has determined the structure of the diamond. In this case the atoms are all of the same kind—carbon. Each atom may be thought of as bound to four other atoms, arranged at the corners of a tetrahedron. This is in accord with the fact that carbon has four chemical bonds and is in good agreement with the structure of the diamond as determined by the methods of crystallography.

We are getting a glimpse, as it were into the inner most structure of the molecules and are learning daily more and more about the manner in which their constituent atoms are bound together.

Electrical Resistance as Effected by Very Low Temperatures—The recent experiments performed by Prof H Kamerlingh Onnes at the Leiden Physical Laboratory on the electrical resistance of metals at low temperatures have excited wide interest due to the unexpected results obtained. For this work Prof Onnes has at his command equipment which enables him to obtain temperature within 1 7 deg Cent. of absolute zero and he can maintain these temperatures for considerable periods of time. He has been studying for some time the electrical properties of metals at low temperatures, and the following is a brief outline of the results of the work as far as reported.

It is well known that the resistance of a metal varies so as to be approximately proportional to the absolute temperature. It is found, however that at low temperatures slight amounts of impurities cause deviation from this law. Cooling an extremely pure sample of mercury Prof Onnes discovered that at a temperature of about 4 2 deg Cent above absolute zero the resistance suddenly became too small to be measured. Just before this change occurred the resistance was 0 002 of the resistance at the melting point. At this temperature the resistance became less than 0 000001 of that resistance. Since, he has found the same phenomena in lead and tin. In lead the change occurs at about 6 1 deg Cent. and in tin at 3 8 deg Cent. above absolute zero. Below these critical temperatures the metal seems to have no electrical resistance and Prof Onnes describes this state by the term supraconductive. The temperature at which a conductor becomes supraconductive is not the same for all values of current but is lower for larger currents. The resistance is therefore dependent upon the current and Ohm's law no longer holds. Other peculiarities of a supraconductor are worthy of mention since the resistance is immeasurably small there is neither any potential drop in the supraconductor nor is any heat developed.

This is well illustrated as follows. The value of the current in a circuit does not instantly become zero when the generator ceases to deliver power but decreases at a rate which depends upon the self induction and resistance of the circuit. The current cannot become zero until all the energy which is stored in its magnetic field has been transferred into heat by the resistance. The length of time for which such a current has a measurable value is extremely short in most cases. If, however, the resistance of the circuit is made very small, the current will be maintained longer before its energy is transformed and we might imagine the limiting case where the resistance was zero and the current continued to flow, requiring no generator to maintain it because it was expending none of its energy. This case seems to have been realized by Prof Onnes. A closed coil of 1,000 turns of lead wire was cooled to a temperature of about 1.7 deg Cent above absolute zero and an electric current of 0 4 ampere induced in it by the removal of an electromagnet whose flux had previously passed through the coil. Prof Onnes was able to maintain the coil at this temperature for 3 hours and 30 minutes and was unable to detect any diminution in the value of the current which was measured by the magnetometer method. At the end of this time the temperature rose to a value of 4.3 deg Cent (absolute) and as a result the current fell to 0 36 ampere, but the temperature again being reduced the current remained constant for 1 hour and 30 minutes more. As a result of his experiments up to the present time, Prof Onnes estimates that the resistance of lead in the supraconductive state cannot be greater than $1/(4 \times 10^{10})$ part of its resistance at ordinary temperatures.

That these results will have an important bearing upon the theories of electrical conduction and molecular magnets there can be no doubt. They also suggest the possibility of being able to obtain by means of supraconductors much stronger magnetic fields than has hitherto been possible.

CHEMISTRY

The field of chemistry is of such nature that it is difficult to select particular discoveries or developments as being the most significant. The following items however are of some interest and importance.

J N Pring has devised a method for the determination of ozone at very great dilutions and low temperatures. By this method it has been found that at a height of about 2 0 kilometers the amount of ozone averaged 2.5×10^{-7} parts while at the height of 3 6 kilometers it averaged $4\ 7 \times 10^{-7}$ parts. This last amount of ozone was found by colorimetric methods to give a distinct blue color indicating that ozone may be a factor in producing the blue color of the sky.

It has been found that metallic salts are dissociated at the temperature of the Bunsen flame, with the result that the metal is set free. This has made possible the preparation of metallic mirrors of copper, cadmium tin silver, lead, bismuth, zinc, arsenic and antimony by precipitation from the Bunsen flame and also the obtaining of mercury in drops.

Mme Curie has shown that the inactive end products of the radio active elements uranium, radium, thorium and actinium are elements which, although occupying the position of lead in the periodic system show differing atomic weights. Among the numerous contributions made during the past year in the field of radio-chemistry are interesting articles entitled Forces between atoms and chemical affinity by J J Thompson and The structure of the atom by E Rutherford.

The controversy regarding the alleged formation of active nitrogen by the electric discharge has finally reached a settlement. The principal investigators now agree that a sample of nitrogen may indeed be made to give the glow more readily when containing a trace of oxygen but that the purest nitrogen is also capable of giving a brilliant glow. The presence of infinitesimal traces of oxygen seems to be favorable to the production of active nitrogen.

Sir William Crookes has measured the spectrum of the purest obtainable (99 98 per cent) elementary silicon. G W Morey has prepared four new crystalline alkaline silicates. In addition to the crystalline products, a series of hydrous glasses was obtained. They are perfectly hard even though containing up to 25 per cent water.

MATHEMATICS

The most valuable recent contribution is that of systematising processes of numerical and graphical approximation. A well known older example of this process is illustrated by Hörner's method for finding (approximately) the numerical roots of an algebraic equation.

Owing chiefly to the activity of Prof. Carl Runge, of the University of Göttingen, a similar process can be applied to a large category of problems, including Fourier's Series, graphical integration, solution of differential equations which define the flow of heat, electricity, etc, adjustment of errors of observation and other problems. Two years ago Prof. Runge gave a course of lectures at Columbia University in which many of his ideas were developed. Since then a considerable number of young men have been working out particular problems connected with it. These are only partly available as yet, the only book being one just published in German, by Dr H v. Sanden, also of Göttingen. It is called "Praktische Analysis." Other volumes of the same series with this scope and its ideas are already in the press. Other applications of the principle are the extension of the uses of the slide rule and calculating machine, and its applications in the field of descriptive geometry.

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* *Sibley Journal of Engineering*

[1] Prof W H Bragg F R S Professor of Physics and Mathematics at Leeds University England gave a special lecture on X rays and Crystalline Structure before Cornell University on December 2nd 1914 under the auspices of the Sigma Xi Society. The above article is a brief abstract of this lecture. For more detailed information see contributions by Prof W H Bragg and W L Bragg in the *Proc Roy Soc* 89 pp 246 291 (1913) and more recent subsequent articles.

ELECTRICAL ENGINEERING

Wireless Transmission—The use of sustained or undamped waves in wireless transmission has long been recognized to offer a large number of important advantages, but the generation of these waves has always been a source of difficulty To produce an alternator of any considerable capacity which will directly generate voltages with a frequency of around 50,000 cycles is an extremely difficult proposition due to obvious mechanical and electrical difficulties

A great many of these limitations have been overcome in the Goldschmidt "reflection" alternator such as is now operating in the transatlantic radio station at Tuckerton, N J

The fundamental frequency of this alternator is about 10,000 cycles, but by an ingenious system of reflection and resonance between the two windings, the output is delivered at a frequency of 40 000 cycles The machine is of German construction and especially rigid in design. The rotor of the alternator is driven by a 250 horse-power direct-current motor, and weighs about five tons. The speed is about 4,000 revolutions per minute, and the air gap is less than 1 millimeter At the normal output of 110 kilowatts, the aerial current is approximately 135 amperes, but it is claimed that the machine is capable of generating as much as 200 kilowatts.

The receiving apparatus is ingenious in that the tone heard in the receiver is the difference tone between the transmitted frequency of 40,000 cycles, and a mechanically produced frequency of about 39,500 cycles, thus giving a 500-cycle tone in the receiver It is claimed that this system eliminates largely the interference from both static electricity and other stations

The Nitrogen-filled Lamp—In these days of such rapid advance in the art as well as the science of illumination, it would be a fearless prophet who would attempt to predict the future of the new nitrogen filled tungsten lamp It is not difficult, however to point out a few types of service for which the new lamp is especially adapted.

Since it is in only comparatively large sizes that we find the remarkably low specific consumption of 0 5 watt per candle-power we shall look for the first commercial development in connection with exterior lighting and the lighting of large interiors.

The efficiency of the gas-filled lamp increases with the diameter of the filament, thus making the high current lamp the first to be put on the market and we find them used extensively on the standard 6.5 and 7.5 ampere lighting circuits. With even better efficiency, lamps drawing a current of 20 or more amperes might be used on alternating current series circuits with a compensator or current transformer for each lamp

Another important class of work for which the new lamp seems peculiarly adapted is in projection lanterns small search lights and in all places where a steady light of high intrinsic brilliancy is desirable

Although the gas-filled lamp may replace the present type of enclosed carbon arc it is a question for the future to decide whether it can compete with the high efficiency arcs such as the magnetite and the quartz mercury lamps While the efficiency of the new mazda is of the same order as that of these arcs, the cost of maintenance is a factor which may be of greater importance than the actual specific consumption of the lamp

It is probable then, that the extent to which the nitrogen filled lamp will be used is largely a matter to be decided by the cost of manufacture and cost of maintenance of several of the better lamps of to-day, and the adaptability of each to special types of service

The Split Phase Motor.—A recent development in electric traction which is important from a technical point of view is the so-called "Split Phase Motor." This motor is not a new traction motor but a motor used as an intermediate step between the line and the traction motors and its function is to change single phase current into polyphase current. It is not a motor generator set but a straight induction motor run as a single phase motor with additional windings so interconnected that polyphase current can be supplied to the traction motors. This motor is kept running continuously and power supplied to polyphase motors only when the car is operated.

The polyphase induction motor because of its simplicity, [illegible] and the possibility of regeneration of power [illegible] ideal characteristics for heavy [illegible]. The chief disadvantage is the complicated distributing system [illegible] and the trouble in [illegible]. The use of the split phase motor [illegible] the use of polyphase motors with single [illegible].

[illegible] on the Norfolk and Western R.R. over the [illegible] Division in Virginia. [illegible] a freight hauling road, traffic [illegible] is ideally adapted to these conditions and in this case proved cheaper to install

The technical journals term this system The Single Phase-Polyphase System

MECHANICAL ENGINEERING

First Stumpf Una-Flow Engine Built in America—The development of the una flow engine promises much for the future of the steam prime mover It is therefore of interest to note the introduction of this engine into America The Ames Iron Works have recently constructed the first una flow engine to be made in this country with the approval of Prof Stumpf

As is commonly known the una flow engine has effected an increased economy because of reduced cylinder condensation losses This is due to the fact that the steam is exhausted at the other end of the stroke from that at which admission occurs Hence the steam in entering is not passed over the cooler end of the cylinder lowered, at the end of the stroke to the temperature of the low pressure steam By eliminating the loss between cylinders, of a compound or triple expansion engine the same power may be developed with a una flow engine having cylinder dimensions materially less than those of the low pressure cylinder of a multiple expansion engine The Stumpf engine built by the Ames Company shows a reduction of 20 per cent in this respect.

The results of tests on this engine recently published show very significant results. The engine is rated at 100 kilowatts, its dimensions are 15x16 inches and its speed is 250 revolutions per minute The best economies are 12 5 pounds of steam per indicated horse-power hour condensing and 16 8 pounds non-condensing (superheated steam in both cases) These economies are indeed remarkable for an engine of such small capacity, but the most significant feature of the performance lies in the flatness of the water rate curves In varying the load from almost zero to 150 per cent of rating the greatest variation is about 2.5 pounds per indicated horse-power hour When the water rate curves of the best multiple expansion engines are considered, these results appear to be almost revolutionary

Extension of the Uses of Surface Combustion—We first heard of surface combustion practically applied, in the surface combustion boiler of Prof Bone of England More recently, however the principle has been extended with marked success into the field of domestic heating and the heating of buildings

Briefly, surface or flameless combustion is effected by premixing the air and gas and impinging a jet of the mixture on a porous surface, in which the combustion takes place When gas is burned in flame combustion the gas jet depends for its air of combustion on the dissipation of gas at the edges of the jet The combustion wave or impulse therefore travels through the gas at a relatively slow rate and the combustion is both slow and often imperfect In the case of a mixture of air and gas the combustion wave travels through the mixture at an explosive rate and combustion is practically perfect This is what occurs in surface combustion the process taking place in the pores of the surface The result is merely a glowing of the surface, entirely without flame It is of course necessary to preheat the surface in order to start the surface combustion This may be accomplished by burning the gas in a flame impinged upon the surface before premixing begins It is further evident that the speed of the jet of mixture must exceed that at which the explosive impulse travels through the mixture in order to prevent back-fire.

One of the most notable applications of surface combustion is in the heating of rooms Ordinary heating systems depend almost entirely on convection for the dissemination of heat through a room It may be seen, however, that the rapid combustion in the pores of the surface by this new method, creates heat in the radiant form This is a much more efficient means of heat transfer for practically all heating purposes The surface combustion room heaters have the appearance of a small plate which is generally located in the ceiling This form of heater seems to be meeting with marked success The surface combustion principle is also being used now in stoves and for other domestic purposes.

The Humphrey Pump—No discussion of recent engineering developments would be complete without mention of the Humphrey pump, being as it is so radical a step in pump design. This subject, however, has received so much attention in the technical press that the reader is referred to this source of information.

CIVIL ENGINEERING

Bridges.—In the field of bridge engineering undoubtedly the most significant development is the use of alloy steel, particularly nickel steel in bridge structures The advance of bridge design has called for steel of much greater strength than that of any carbon steel. The demand has resulted in extensive research on the properties of alloy steel with the result that nickel steel has been adopted quite extensively for this class of work The most notable examples of the use of this steel are three large bridges now building viz the Hell Gate bridge in New York the new Quebec bridge and the bridge at Memphis Tenn which spans the Mississippi River The last named bridge is being built alongside of the old bridge at that point so that an exceptional opportunity is afforded to contrast an old time structure with the most recent design

Railroad Engineering—The most important recent developments in railroad engineering may for convenience be grouped under construction operation and management

The construction work in this country has been largely in the reduction of gradients and curvature and the improvement of terminals the former to reduce the cost of transportation and the latter to increase its convenience The former has been largely an economic problem the increased cost of transportation over the sharp curves and steep gradients for the heavy traffic becoming greater than the interest and maintenance for the new construction

The latter has involved a large amount of expensive grade separation work in reaching the centers of population to reduce delays due to street travel and to increase safety for both the street and railroad travel To quite an extent, this has been forced upon the railroads by public opinion but it has usually been found profitable in the development of suburban business and in saving of time and increased safety but in the construction of some of the recent large passenger stations the economic limit has been passed even after allowing for the advertising value in attracting competitive traffic

In operation on the low grade lines with heavy traffic the strength and safety of track limit the speed and weight of train For dense traffic the unit cost decreases with increasing weight which makes a constant demand for stronger track A few years ago the defective rail was the limiting factor but thanks to the work of the rail experts and the keen interest of both the rail makers and the rail users the open hearth steel rail of to-day is giving excellent service The tie plate is rapidly coming into use for both safety and economy while the screw spike is being tried extensively It is felt by many that the ballast and sub-grade will also require strengthening for any further material increase in wheel loads or in loads per foot of track

The safety first movement is having its effect on those responsible for the operation of trains as well as upon those responsible for roadbed and equipment.

The thorough investigation of earnings which has been made in connection with the request for an advance in freight rates is having an excellent effect in bringing about a study of the economics of operation which should result in mutual benefit to the railroads and the public while the physical valuation by the Interstate Commerce Commission may not prove to be such a calamity as at first predicted

X-Ray Diffraction Patterns

A CORRESPONDENT of *Science* Mr W W Strong of the Carnegie Institute says

The diffraction patterns discovered by Friederich Knipping and Laue have been shown to be due to the arrangement of the atoms of crystals into planes These patterns are used to indicate the spatial distribution of atoms in crystals

An experiment illustrating these patterns can be very easily shown to an audience by permitting a beam of light to enter a dark room and fall upon the face of a diamond such as used in rings The diamond is held a few inches from the hole through which the beam of light enters and upon this screen is thrown a large number of bright spots very closely resembling the X ray patterns By moving the diamond to and fro from the screen or by rotating it the form of the pattern can be altered The portions of rays that enter the diamond and are reflected from the rear surfaces may show the spectral colors.

This experiment can be demonstrated to a class very easily and should be of some use in explaining crystalline structure

A Shortage of Wood-pulp Threatened

A REPORT by the Forest Service of the U S Department of Agriculture states that because of the war English manufacturers and consumers of wood pulp have been caused considerable uneasiness. Production is at a standstill in the countries at war and in Norway and Sweden, principal sources of supply mills have been greatly hampered because of a lack of coal and chemicals. England has practically no domestic sources of pulp.

An X-Ray Inspection of a Steel Casting*

Experiments on a Method for Discovering Hidden Defects in Metal

By Dr Wheeler P Davey, Research Laboratory, General Electric Company

It has always been true that as soon as a new tool is perfected unsuspected applications of that tool rapidly develop This has been especially true in the case of the Coolidge X ray tube It is planned to publish from time to time results of such special applications as may come within our experience Possibly the question of observing the pipe in a steel ingot by the use of the X ray thereby being able to determine just where the ingot should be cropped may seem still somewhat removed at least in so far as commercial applications are concerned There is no inherent impossibility in the process however The case now being described is a long step in this direction It is the object of this article to describe in detail what has already been done in the way of an X ray examination of a certain steel casting of which suspicion had been aroused as to its homogeneity when in the machine shop

The original casting was two and one half inches thick and weighed about a ton When received at the Schenectady Works of the General Electric Company it had been machined down to approximately the desired shape and thickness The amount still to be taken from the faces was not more than one eighth inch and in some places was only one sixteenth inch but when this was removed it was found that some small imperfections had been cut into These extended over an area about five inches long and one and one half inches wide

The mechanical department at once chiseled away a part of the surface at this point, and then sent the casting to the Research Laboratory to determine if by means of an X ray examination it might be possible to reveal still other hidden blow holes or imperfections

A Coolidge tube especially made for use on high voltages was set up in front of that part of the casting where the imperfections had been found An 8 by 10-inch Seed X ray plate was mounted immediately behind the casting and the plate was backed by a large sheet of lead The distance from the source of X ray to the plate was 20 inches The tube was excited by an induction coil with a mercury turbine interrupter The current through the tube was 1 25 milli amperes and the potential across the terminals of the tube corresponded to that sufficient to break down a 15-inch spark gap between needle points The X ray plate was exposed two minutes At the place where the radiograph was taken the finished casting was about nine sixteenths of an inch thick The radiograph obtained is shown in Fig 2 The casting was then moved eight inches and another radiograph made In this way a number of exploratory radiographs were taken through different points of the casting

All the radiographs thus taken showed plainly the tool marks on the surface of the casting. *All but one* showed peculiar markings which were of such shape as to strongly suggest that they were indeed the pictures of holes in the interior In the words of the surgeon it was decided to confirm the diagnosis by making an exploratory incision A circular piece, one inch in diameter was punched from the casting at a point where one of the radiographs indicated that a blow hole should be found (Location of sample shown by circle on Fig 3) Figs 4 and 5 show that the surfaces of the casting were entirely free from blow holes at the point where the button was removed Figs. 6 and 7 show the ends of the hole in the button

This has proved then that with the proper X ray exposure blow holes or cavities may be disclosed in apparently solid metal of considerable thickness. A careful comparison of the X ray photographs and the button photographs leads to the conclusion that very small air inclusions are made visible and the fact that the tool marks are plainly visible on the X ray plate confirms this fact

Such studies point to the desirability of great care in metal casting where imperfections ordinarily invisible are of great danger and where X-ray analysis or some other method is not used to check them

* Courtesy of the *General Electric Review*

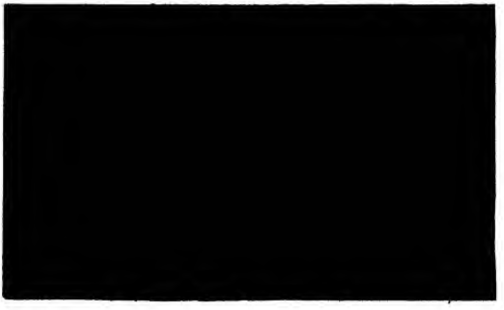


Fig 2—Radiograph of steel casting

Some of the imperfections have been chiseled out of the steel The chisel marks and some remaining imperfections show plainly

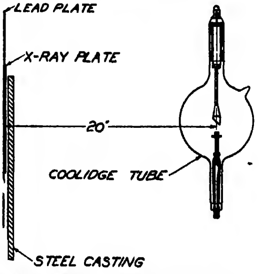


Fig 1—Diagram of set up for taking pictures of steel casting Drawn to one eighth scale.

Fig 3—Radiograph [illegible]

The circle shows [illegible]

Irrigation With Fresh Water from the Sea*

By E. J Meyaihan

There are many parts of the earth's land surface quite near the sea and at a very low elevation, where little rain falls, which are actually or nearly desert. A great part of the Sahara, certain parts of Australia, and portions of South Africa, fall into this category These, and many other parts of the world at a greater elevation now useless for lack of natural water, and so placed that no ordinary irrigation scheme is applicable, could be transformed into fertile provinces, like the irrigated deserts of the Western States of America, if a cheap supply of fresh water for irrigation purposes could be brought to them

It is not necessary to prove that the cost of fairly long canals to bring the water to the spots to be irrigated is not prohibitive Such canals for gravitation systems of irrigation, already exist, as paying concerns in large numbers all over the world In the case of water brought from a lower level it is necessary to show that in many cases the cost of pumping is not prohibitive either

In dealing with the cost of pumping I shall take the head of water produced by the pumps to be 50 per cent more than the actual height to which the water is to be raised I shall allow roughly for an efficiency of 75 per cent in the pumping plant, in addition to the absorption of one-third of the energy delivered to the water by the pumps in friction in the water channels. Assuming an annual requirement of 2 000 tons of water per acre (which is approximately equal to a 20-inch rainfall) 100 feet of effective lift calls for the expenditure at the pumps of

$$\frac{2 \times 2000 \times 2240 \times 100}{33000 \times 60 \times 24 \times 365}$$

* Read before the South African Institute of Engineers

of approximately one-twentieth of a horse-power year On a large scale and in favorable situations electric power can be produced from coal for less than £5 per horse-power year The pumping charges for water per acre would therefore be on the above basis, something like 5 shillings per acre, which is by no means prohibitive. Irrigated land, formerly almost worthless has recently changed hands in South Africa at about £200 per acre. The interest on this value at 5 per cent would pay forty times the annual charge which I have calculated.

This annual charge might in the future itself easily be reduced to a fifth of the figure I have taken If this is done irrigation at an elevation of 5 000 feet with water pumped from sea level would be practicable With modern improvements in gas making and the attention that is being paid to the recovery of the waste products in the gas-making process it is quite conceivable that the power-gas might become the waste-product The present type of gas engines are capable of very great advances in thermal economy It would require no very great improvement of this kind to bring down the fuel consumption to ¾ pound of carbon or coke per electric brake horse power per hour or less than 3 long tons per year At 5 shillings a ton the cost of fuel for power would be reduced to 15 shillings per annum per horse-power or about one-sixth of the £5 per horse-power year that I have taken above. This reduced figure takes no account of by-products on the one hand or capital charges on the other These two items might easily balance one another

To bring great supplies of water from a distance implies the use of very large channels, which are very expensive if made artificially In the case of supplies brought from the sea, where the water is to be raised from a lower to a higher level these channels are there already in the existing streams All that is necessary is to dam them cheaply so as to give moderate lifts of, say, 4 or 5 feet, at the narrowest parts of their courses. The flood water of the rivers could then be partly stored in up-country irrigation dams, and partly allowed to go out to sea to prevent "silting-up" The pumping stations would be advised by telegraph or telephone in advance of the arrival of the floods, or automatically controlled so that they would do no unnecessary work.

The streams, treated in this way, would also serve for the cheap transport of fuel and other material, including such parts of the crops produced as were in no need of hurried travel. At even two miles an hour, goods would only take about four days to travel 200 miles, which is not so very much slower than the actual rate of travel for coarse goods over similar distances, when truck demurrage is taken into account. By adopting a system with automatic loading and discharging the expense of bringing coal to the pumping stations would be reduced to a very low figure. At this speed [illegible] 1 horse-power hour will do about [illegible] against a 2-mile current.

[illegible] of the proposed modes of turning salt [illegible] water [illegible] cheaply as to make the scheme [illegible].

[illegible] solutions of the problem. Chemical means I shall reject for the purpose of this paper because in the first place I don't know enough chemistry and in the second place it is only necessary to show the feasibility of physical methods

A simple physical method of purifying salt water is to distill it. To make this commercially practicable it is necessary to do one of two things The first is to have a large source of heat available at low cost The second is to adopt such a method of distillation that the latent heat of evaporation is practically all recovered from the latent heat of condensation I will show that both these methods are practicable

The cheap source of heat for the first method is in the sea itself It is known but not generally known that the temperature of sea water varies considerably with depth The variation differs in different places but it may be taken as averaging something between 4 deg and 15 deg Fahr per 100 fathoms of depth There are therefore many places where unlimited supplies of water are available at temperatures differing by say 5 deg Fahr the warmer water being on the surface and the colder water at a depth of from 30 to 60 fathoms These spots should be prospected for In Summer when irrigation water is most needed the temperature gradient is very much steeper than the above figures show especially in hot latitudes In the English Channel at Station E, in August 1904 the gradient was about 8 degrees for 8 fathoms In the Central Pacific a difference of 30 degrees has been observed for 100 fathoms In the Red Sea the conditions are probably similar to those of the Pacific It is therefore probable that for those months in the year in which water is most needed there are suitable places near shore where a temperature difference of 5 degrees exists in very moderate depths of water It is hardly necessary to tell engineers that under these conditions it is easy to evaporate the water at the higher and to condense it at the lower temperature

As we have to deal with very small differences of pressure the condenser plates may be made of very thin metal as thin or thinner than an ordinary sheet of galvanised iron

With suitable circulating methods each square foot of condenser surface would produce about 2 pounds of condensed water per hour for a temperature difference of 4 deg Fahr or roughly 8 tons per year For the 2 000 tons assumed as the requirement per acre 250 square feet of condenser surface at 6d a foot would mean a capital expenditure for condenser surface of £6 5s. per acre to be irrigated

The calculation of the surface required is based on the assumption that about 500 heat units are transmitted per square foot of condenser surface per hour per Fahr degree of temperature difference With proper design and circulating arrangements it is possible to increase this figure to more than 3,800 or more than seven times as much (See foot-note p 593 of "The Steam Engine," by Perry) This would reduce the capital cost for *condensing surface* to less than £1 per acre to be irrigated.

With the use of rivers as main irrigation channels as suggested, there would be no need to take channel evaporation into account, as the natural flow of the rivers already accounts for this, and the back percolation of the water from the irrigated land to the river channels would also offset the evaporation

An evaporation plant based on the above facts and figures would necessarily deal with very large quantities of water in order to be a payable proposition The intakes for the circulating water would have to deal with such quantities of water as pass out to sea by small rivers But as their cross-section would be comparable with that of rivers, so the friction head required for circulating purposes would also be of the same order or something like a head of 1 inch for 100 feet of conduit The stresses on the conduit would also be as nearly negligible as the difference in pressure between the outside and inside of the pipe The material of which the conduit was made could therefore be quite inexpensive The condenser plates could be immersed in the water at the top of the conduit itself Assuming that the condensation water only took up one heat unit per pound of water condensed and that the pumping head required would be as much as 3 inches the work done on the condensation water by the turbo-pumps would be equivalent to lifting the condensed water 250 feet This I have already shown, by implication not to be financially impracticable The work to be done at the distilling plant on the condensed water is still less so being only a small fraction of the work done on the condensation water The total pumping work to be done at the evaporator calls for an expenditure of from 6 shillings 3 pence to 25 shillings for power per acre irrigated with power costing from 50 shillings to £10 per horse-power year

The second method of distilling the water consists of increasing the pressure and therefore raising the temperature of the distilled vapor or the water to be distilled by mechanical means such as a compressor turbine and condensing the vapor in a surface condenser the condensation water being the same water that is being evaporated In this way the whole of the latent heat of condensation is returned to the water which is being condensed The net amount of heat supplied mechanically depends on the difference of temperature between the condensed water and evaporated water

Taking this as 4 degrees the net amount of heat is substantially 4 heat units per pound, or about 9,000 heat units per ton of water evaporated With an efficiency of 25 per cent over all in the gas-engines and mechanical arrangements less than 5 pounds of carbon would therefore be consumed to distill 1 long ton of water With a requirement of 2 000 tons of water per acre irrigated the carbon consumed annually per acre is slightly less than 2 7 tons costing at 5 shillings to 20 shillings a ton from about 13 shillings 6 pence to 54 shillings per annum for fuel The fuel bill could be proportionately reduced by reducing the temperature difference

With this second method of distillation no works would be necessary in the sea itself The apparatus would all be inshore with a canal leading water to it from the sea at one end and taking water away at the other One great advantage of this second method of distillation is that much less water has to be handled than in the first. Practically all the water requiring handling is that required for distillation and irrigation The latent heat withdrawn from the water distilled being practically all returned to it in the act of condensation the natural tidal circulation is sufficient to renew the main body of water dealt with rapidly enough to carry the increasingly saline water out to sea Taking capital into account this second method is probably cheaper than the first method of utilising the heat in the sea water itself

The second method has other conveniences It can be run profitably on a much smaller scale than the first, it calls for less capital expense and it can be used to produce water all the year round under almost uniform conditions. This would allow of deeply ploughed ground being cultivated on a system combining the advantages of dry farming and irrigation in such a way that the water could be used evenly as it was produced all the year round

Fig 4.—Photograph of top surface of casting at place where piece was punched out
Note that no imperfections are visible The U is a punch mark to identify top of piece cut out

Fig 5.—Photograph of bottom surface of casting at place where piece was cut out
Note that no imperfections are visible at the surface

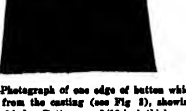


Fig 6.—Photograph of one edge of button which was cut from the casting (see Fig 3), showing position of hole. Button was 9/16-inch thick.

Fig 7.—Photograph of edge of button opposite to that shown in Fig 6

Impact from Flat Wheels

Tests have been made at the Purdue University to determine the effect of impact resulting from flat wheels and the investigations covered spots of varying sizes and wheels running at different speeds and with varying loads It has been found that an imperfect wheel with a 3 inch flat spot strikes the track with an impact of 104 000 pounds when the car is going 16 miles per hour and is carrying a load of 20 000 pounds It was also found that under similar conditions a flat spot only 1½ inches in length produced a blow of 20 000 pounds, and the impact for spots 2 inches long was 25 000 pounds A standard freight car was mounted in the test laboratory and special apparatus, including an instrument which recorded photographically the magnitude of the blows, was employed to collect test data

The European War and Potash Supplies

A Consideration of the Possible Sources of Material for Home Manufacture

By Thomas J. Keenan

In the closing years of the eighteenth century, when the French revolution was at its height, conditions in France as regards the supply of soda bore a curious resemblance to the situation in America to-day as regards our supply of potash, the political conditions being of course very different. France was wholly dependent on Spain for barilla, a variety of soda ash made by burning saltwort and sea plants, and also imported large quantities of Spanish potash. Commercial intercourse between France and Spain had ceased on the outbreak of the revolutionary war, and all the potash which France produced was required for the manufacture of saltpeter and gunpowder in this emergency. The National Convention made an appeal to the chemists of France to devise a process in which common salt might be made available as a source of soda. The call was heard by an obscure chemist, Nicolas Leblanc, who came forward with a process for the conversion of sodium chloride into sodium carbonate that has made his name an immortal one in the annals of chemistry. The Leblanc process has never been entirely superseded; indeed new plants are constantly being established, despite the superior advantages of the Solvay process for most purposes in the production of carbonates of soda.

Now that the supply of German potash for agriculture and industrial uses has been cut off completely by the European war, a situation has been created in the United States not very dissimilar to that which prevailed in France in revolutionary days, and fame and fortune await the American inventive genius who will arise to solve the great problem of producing potash economically and abundantly from the potash rocks, brines, and bitterns native to the United States. Leblanc achieved fame, but died a pauper.

The primitive product of the lixiviation of wood ashes, known for centuries as potash, is not an article with which twentieth century chemists can lay claim to much, if any, familiarity. The article supplied in sticks—potassium hydroxide—is what is recognized as potash in the laboratory. Our forefathers knew the wood ash product better, and there are doubtless many now living who can recall early days on the farm when potash was collected for domestic soapmaking by the simple process of leaching the ashes of burnt hickory or other logs. A century or more ago, however, when vast natural forests existed and the value of lumber was little more than that of the labor of felling it, the manufacture of potash from wood ashes was an industry of considerable importance.

Although potash is still manufactured from the ashes of wood in the forests of Northern Michigan and in portions of the provinces of Canada, the quantity so produced is negligible and finds use in a local way only.

The German potash industry dates from 1861, when the first factory for refining crude potash was established by Prof. Adolph Frank at Stassfurt. Stassfurt has been known for its salt industry for more than 500 years, the records of the town showing that a guild of saltmakers had worked the salt beds of the district as far back as the thirteenth century. At the time the deposits were taken over by the Prussian government in 1798, and some time later worked on a commercial scale, the potash was treated as a useless by-product, but the researches of Justus von Liebig in agricultural chemistry in 1860, having established the fact that plants depend for their nutrition on the existence in the soil of nitrogen, potassium, and phosphorus in certain definite proportions, and that it was useless to feed a plant on nitrogen and phosphorus unless the right proportion of potash was also supplied, intensive inventive work was begun to discover sources of soluble potash. Liebig's discovery had the effect of directing efforts to the extraction of the potash from the salt beds at Stassfurt as a main product, and this was successfully accomplished after the establishment of the factory by Frank. The potash salts were henceforth worked exclusively and salt became the by-product. In this way was developed the great German potash industry on which the whole world is now dependent for its supply of soluble potash for use in agriculture and the industries.

At the outbreak of the war Germany was exporting annually to the United States 1,115,505 tons of potash for use as fertilizer and in the manufacture of chemicals, this representing about one tenth of the annual output of the German mines, which exceeds eleven million tons.

The German potash minerals are now mined over a large extent of country, and it is no longer accurate to speak of them as "Stassfurt deposits." Reaching to a depth, from the top of the upper to the bottom of the lowest stratum, of some 5,000 feet, the beds underlie a tract of country extending from Stassfurt to Thuringia on the south, to Hanover on the west and to Mecklenburg on the north; while deposits were discovered and mines opened a few years ago in Alsace near Mülhausen, where the German troops are now repelling a French invasion.

Notwithstanding the apparently inexhaustible extent of the German salt deposits they are really insignificant compared with the abundance and variety of potash rocks (feldspar, etc.), which occur everywhere in the earth's crust. It is their solubility in water and consequent ready amenability to chemical treatment which gives the German salts their great industrial importance, and makes it appear altogether impossible for any other known sources of potash-containing minerals to compete successfully with them. Deposits similar to the German have lately been discovered in Spain, and, if they prove to be as soluble and as accessible, competition may be expected, but adequate reports on this source of supply are not available at the present time.

Although German potash is not contraband of war and none of the nations at war objects to its movement in neutral ships, it has not been possible to move it from the mines and storehouses to the coast on account of the monopolization of railroad and river traffic by the army and navy, so that not a ton of potash has been shipped to the United States since hostilities started last August.

Potash has a wide and necessitous use in many fields of industry besides pharmacy—in agriculture, glass manufacture, and soapmaking, to mention some of the more important. The serious problem now confronting the country is to find substances that will yield water-soluble salts of potash in sufficient abundance to provide relief from the deprivation of the German supply and at the same time put our farmers and chemists in a position of economic independence for the future.

The mineral sources of potash include the salts and brines found in the lake basins of the arid West, notably in Utah, Nevada and California; the mineral alunite, a double sulphate of potassium and aluminium, lately found near Marysvale in Utah; and certain natural silicates or potash-bearing rocks, as feldspar, etc. Although a great deal has been published concerning potash mines and deposits in Nevada, no one out there appears to have ever heard of their being worked.

Kelp, or seaweed, contains a notable quantity of potash in combination with chlorine, and the stretch of giant algæ groves on the California coast are rich in potassium chloride, being estimated to contain up to 30 per cent of potash in the ash, and in some cases up to 2 per cent of iodine, which substance it is considered would largely pay the cost of production of the potash.

The most promising source among the lake beds of the West is Searles Lake in San Bernardino County, California. Borings show that the deposits in this lake bed consist of a mass of salts about 70 feet thick. These salts are made up of sodium chloride. The structure of the mass reveals a coarsely crystalline and honeycombed form, the spaces being filled with brine. Below a salt bed extending down for a distance of 23 feet, a brine is found which analyses about 4½ per cent of potassium chloride. A plant has been recently started for the extraction of the potash by a spraying and evaporating process. This is expected to have an output of 120 tons a day when working at full capacity, but the entire deposit, according to Government estimates, amounts to only 600,000 tons —less than a year's supply!

A promising source of potash as a by-product is the Portland cement industry. By replacing the clay ordinarily used in cement manufacture with finely ground orthoclase or potash feldspar, it would be possible to obtain as a by-product a quantity of potash equal to about one million tons a year. Any granite rock, gneiss, feldspar, or phonolite would do as a substitute for clay in this process. All that is necessary would be to grind the rock, mix it with limestone and heat the mass to a higher temperature than is ordinarily done in cement work, or say, 1,400 deg. Cent. The potassium is driven out by the lime, and converted into a carbonate, more or less mixed with impurities from the cement, but easily soluble and readily refined. The product obtained by this process is said to yield 65 per cent or more.

Among the minor sources of potash that might be worked for industrial purposes, for the manufacture of pharmaceutical salts, etc., the waste liquors from the manufacture of beet sugar are worthy of note. Some 15,000 tons of potassium salts are obtained annually in Germany from this source alone, and as Prof. Lloyd has pointed out, the waste liquors of the French beet sugar industry were at one time a fairly good source of potash, large quantities of a crude carbonate obtained in this way being at one time imported by American chemical manufacturers. On the assumption that the molasses of the American beet sugar industry contain the same proportion of potassium that is present in the German and French sugar beets, there would seem to be an opportunity in this country for the exploitation of potash manufacture as a by-product of this industry. Beet molasses, or the residues left after the extraction of the sugar, contain the total potash salts of the root. This material is either charred directly, yielding *schlempkohle*, or it is desaccharised, or fermented and the final liquors (*vinasse* or *schlempe*) from these processes are evaporated to dryness and the residue calcined to a black porous mass which, after appropriate treatments, yields a product containing about 85 per cent K_2CO_3 and 8 per cent Na_2CO_3.

It has also been suggested that the waste liquors of the sugar industry in the South might be utilized as a source of potash, but it is not known how large a yield might be expected, or if the process of extraction could be operated so as to prove a commercial success.

An interesting source of potash is sheep's wool. In the internal economy of the sheep, the potash ingested by the animal as constituents of the roots, herbs, and grasses on which it feeds, is excreted mostly as sweat, one third of the weight of raw merino wool being said to consist of potassium compounds. No attempt has been made in American sheep-raising districts to save this potash, though in France as much as 1,125 tons of wool potash are produced annually by several wool-washing plants. Wool yields about 150 grammes to 190 grammes of potassium carbonate per kilo of combed wool, or from 16 to 19 per cent of potash. The raw wool is washed with cold water, whereby the potash soaps, with some of the neutral fat and cholestrol, are extracted. The solution is evaporated to dryness and calcined, giving a residue containing about 85 per cent K_2CO_3, the remainder being Na_2CO_3, together with K_2SO_4 and KCl.

Among plants the ashes of which are particularly rich in potash, sunflowers, tobacco, and fumitory may be mentioned. Potassium carbonate once went by the name of salt of wormwood, the ashes of this plant being largely used at one time for its production, just as it was called salt of tartar from the fact that cream of tartar was once employed as the source of a pure article. In a table published in Crooke's translation of Wagner's "Chemical Technology," the following figures are given of ash and potash yields of 1,000 parts of the woods named:

Wood.	Ash.	Potash.
Pine	3.40	0.45
Beech	5.80	1.27
Ash	12.20	0.74
Oak	13.50	1.50
Elm	25.50	3.90
Willow	28.00	2.85
Vine	34.0	5.50
Dried ferns	36.4	4.25
Wormwood	97.4	73.00
Fumitory	219.0	79.90

Familiarity with the extent of the available supply of potash in Germany, and the cost of production there, leads to the conclusion that it would be a hopeless undertaking to attempt competition with our present resources. If 150 of the mines now worked in Germany were to cease producing potash, enough would be available in the forty remaining mines to supply the world's requirements. It is said that [illegible] of potash sold could be mined, refined and [illegible] at the port of New York for about [illegible] a ton and still clear a profit, if the authorities [illegible] were compelled to do so by stress of competition. The price paid in cargo lots by American [illegible] grade of potash is from [illegible] a ton. [illegible] realized explains why the Kali [illegible] a million dollars a year [illegible] fourth of which is [illegible] United States.

Discoveries About Bacteria*

A Simple Description of What They Are and What They Do

By Sir Ray Lankester, K.C.B., F.R.S.

The London newspapers are afflicted by a dangerous eagerness to provide their readers with short articles announcing "something new." I am sorry to say they are sometimes not very particular as to whether their announcements, when relating to matters of physical science, natural history and medicine, are true. It would take up much space were I to give a complete list of the items of rubbish which are now being daily foisted on the newspaper reader by ignorant writers, who are encouraged by some newspaper proprietors to write "smartly" and "informingly" about scientific and medical subjects of which these writers are ignorant and concerning which they make outrageous blunders.

I will here notice only one of these recent misleading announcements. It relates to a subject which, when properly dealt with, may be of great interest, but can easily be made a meaningless absurdity. A paper communicated to the Academy of Sciences of Paris by Dr. Roux, the director of the Pasteur Institute, was written by Madame Victor Henri, and describes some observations made by her and M. Victor Henri in the laboratory of Dr. Borrel in the Pasteur Institute, with regard to the change of character caused by the action of ultra violet rays of light acting on the bacterium known as "Bacillus anthracis," which is the minute microscopic "germ" or infective parasite causing the deadly disease known as "splenic fever," "anthrax," or "charbon" in cattle and sheep, and as "malignant pustule" in man. This little paper is an interesting contribution to the subject. But somehow or other its title attracted the attention of the Paris news purveyor, and accordingly we had it announced by telegrams to London papers as a wonderful revolutionary epoch-making discovery which must at once be proclaimed to the British citizen at his breakfast table. He was naturally inclined to ask, "Who on earth cares if the ultra something rays do act somehow or other on bacillus what's its name?" Since most people must be as no doubt was desired mystified by the announcement, and some perhaps soothed by its phraseology as by the blessed word "Mesopotamia" (in fact as we may say "mesopotamified") I will endeavor to state in plain terms what it really amounts to.

The name bacterium—meaning a short rod—was applied a hundred years ago to a common rodlike microscopic form (often only one twenty-thousandth of an inch long and a third of its length in breadth) occurring by millions in putrefying vegetable and animal refuse, and well known to all who used high powers of the microscope to explore natural waters such as ponds and sea pools. They were first seen and described 230 years ago by the Dutchman Leeuwenhoek, who found them in millions in the human mouth. Each rod multiplies by dividing as it increases in length into two. From a single rod many millions are thus produced in the course of 24 hours. The Austrian botanist Nägeli, about sixty years ago, gave them the name "Schizophyta" or "splitting plants" on account of this mode of rapid multiplication. According to the nature and abundance of the material (animal and vegetable refuse) in which they are growing, they assume different simple forms. Some grow into long hair-like filaments before splitting into small rod-like bits; others break up into tiny spheres, called "cocci" or "micrococci;" others take on a spiral, or corkscrew form, and are called "spirilla," and break up into little curved bits called "commas," or "vibrios," while others, rod-shaped like the original "bacteria," but a little longer in proportion to breadth, are known as "bacillus." Often they are motile, being provided with one or more excessively delicate vibrating threads of protoplasm, which keep them in constant and rapid movement. The same kinds will, under certain conditions, cease to move, and throw out as they grow and multiply an abundant jelly, in which they are embedded. Most of them can withstand the effects of the drying up of the moist matter in which they grow, and are blown about as dust, apparently dead, but revive into active life when they fall into liquid, or on to a moist surface. Consequently, they are ubiquitous, and we know of hundreds of kinds of them occurring in almost every imaginable position where their proper nourishment, namely, the moist substance of living or dead animals or plants, can be found. Not only can they resist the temporary suspension of their life by dryness, but some are not killed by exposure to the heat of boiling water for some minutes, though most are killed by heating to that or a somewhat lower temperature. Great cold, even that of liquid air, does not kill them, but suspends their life so that they recover with increase of temperature. Strong sunlight kills them, some kinds more quickly than others. They are chemically altered and soon killed by the invisible ultra violet rays which accompany the light rays which act upon our eyes. Those rays are given out by the sun and by many other incandescent or light-producing bodies, such as gases and the vapors of metals heated in the electric arc of electric lamps. But of course these rays do not in natural conditions fall on to the "bacteria" which are concealed beneath the surface of opaque masses of refuse in mud and inside living animals and plants.

The bacteria are not only excessively minute, but the simplest of living things in visible structure. They are just rods or granules of living protoplasm with a dense surface and a granule or two or a liquid-holding space within. They do not possess the peculiar active central kernel or nucleus which is characteristic of the protoplasmic cell units of animals and plants. Nevertheless they have the most prodigious chemical powers and an astounding variety of such power. They do not feed as green plants do by decomposing carbonic acid with the aid of that real marvel "leaf-green" or "chlorophyll;" they do not take carbon from carbonic acid and nitrogen from nitrates. Nor are they limited to the albuminous substances of flesh and of plants for the necessary nitrogen of their food, as are all animals. They have very special and varied powers of digestion, like those of the molds, yeasts and fungi—the colorless plants. They do not digest their food as animals do by taking bits of it inside them and there chemically operating upon it. Their food does not get into them as does that of animals, but they get into it. They set up most remarkable and definite chemical changes in the animal and vegetable refuse in which they multiply, changes which may be compared with those effected in the stomach and intestines of animals where they are called digestion. Gradually chemists are getting to know the nature of some of the digestion-like changes produced by different kinds of bacteria. But their full discovery requires the greatest skill and delicacy of experiment and has yet to be attained. The chemical action exerted by another class of minute vegetable organisms, the yeasts, when they cause fermentation, breaking up the sugar of malt in the brewer's vat into carbonic acid and alcohol, is similar to the chemical action of many bacteria. They feed and multiply in the process of chemical fermentation which they cause, just as the yeast plant does. Putrefaction with its accompanying foul-smelling gases and destruction of dead animal and vegetable matter is a fermentation caused by bacteria, just as the production of alcohol and other bodies from sugar is the fermentation caused by beer yeast.

All the dead bodies and waste excreta of all animals and all plants on the surface of the globe are thus broken up by bacteria. Putrefaction and decay is the result of life, the life of bacteria, and not of death. All bad smells except those made by chemists are made by bacteria. If there were suddenly a destruction of all bacteria the earth's surface would be encumbered by the unchanged bodies of its animals and plants as they died and accumulated. Not merely that, but all the carbon and nitrogen would be fixed and "held up" in those dead bodies—for the putrefaction caused by the bacteria is carried on step by step—until those essential elements are returned to the water and the soil of the earth as carbonic acid and nitrates. The green plants must have the carbon and nitrogen of their food in the stable, simple soluble chemical compounds called carbonic acid and nitrates. They cannot feed on the carbon and nitrogen built up into the fat, sugar and albumens of other plants and of animals. If these were not chemically broken down by the bacteria into carbonic acid and nitrates, the green plants would cease to exist, and so would the vegetarian animals which feed on them, and the carnivorous animals which feed on the vegetarians, and there would be an end of the whole world of life! The bacteria are the necessary agents for keeping the carbon and nitrogen in circulation, breaking the complex chemical compounds of the bodies of animals and plants down to the simple carbonic acid and nitrates and so returning them in the necessary state of simplicity to the primary builders-up of living substance—the green plants.

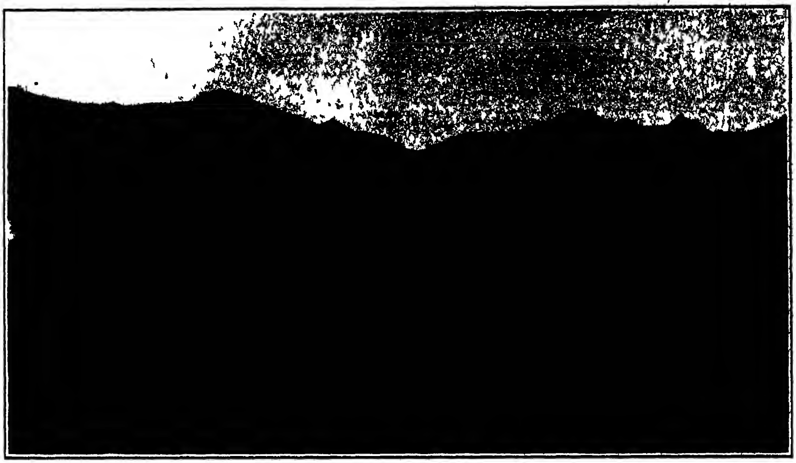
Among the important chemical operations of bacteria are the bringing about of "oxidation" or combination of oxygen with other substances. Different kinds of bacteria, separable to some extent by their shape and growth as seen with the microscope, but more clearly dangerous by picking them out from their fellows by means of cultivation, sowing them like seed on nourishing films and isolating them, and then testing their properties—are responsible for different chemical operations. Some require the presence of free oxygen for their growth, others can do without it (and are called "anaerobic"); some will flourish in weak acid fluids, others are killed or arrested in growth by acid and require alkaline fluid. Some live in the soil or in the waters of the sea, in rivers or pools, others live on the surface of the bodies of plants and of animals, others inside in the mouth, in the intestines or in the blood and tissues of animals or in the juice of plants. Besides the commoner putrefactions which we recognise by their unpleasant smells, there is a kind of bacterium which makes sour milk, that is, converts the sugar of milk into lactic acid; another to which we owe vinegar, converting alcohol into acetic acid; another which gives flavor to cheese by producing butyric acid, and others producing other flavors. Others of great importance are first one which breaks down organic matter already made putrescent by other bacteria into ammonia (familiar through the smell of "stables"), another which oxidizes ammonia into nitrous acid, and another which oxidizes nitrites into nitrates. These are of essential importance in agriculture and in the change of sewage and natural refuse into food for green plants.

While they are ubiquitous and active and essential in a thousand ways in the world around us, the bacteria have a more personal interest for us when they operate on and in our bodies. They cause fermentations and produce various and often deadly poisons within us. The intestine is full of them, one-third of the solid matter in it being bacteria, and these of many kinds, some harmless, some producing injurious poisons from the undigested food which may be absorbed into the blood. The diseases known as septic poisoning, typhoid fever, cholera, diarrhœa, diphtheria, erysipelas, glanders, anthrax or malignant pustule, pneumonia, influenza, common catarrh, leprosy, tubercle, infantile paralysis and others have within the lifetime of many of us been shown to be due each to a specific kind of bacterium producing specific poisons by its life processes and the chemical fermentations which it sets up in this or that part of the body.

The question has naturally arisen—is each of these enormous and terrible array of bacteria a different kind—that is a different species? Or can one kind become changed and altered in its character and activities by change of conditions so that possibly a harmless non-poisonous kind of bacteria living outside the body, might become altered by parasitic life and change into one that is deadly and poison producing? During the past thirty years experiments and investigations on this question have been constantly carried on. One of the earlier suggestions (due to Büchner) was that the anthrax bacillus is the same organism as that common in hay, the hay bacillus, which it much resembles in form and growth. But after careful experiment the supposition has not been confirmed. Experiments on the possibility of altering the form and the chemical activity of bacteria by growing them in novel conditions have been numerous. It was discovered by Pasteur that by growing certain parasitic disease-producing bacteria—outside the body in the presence of oxygen—their virulence as poison producers could be greatly diminished. Recently a paper was communicated to the Royal Society by Mr. Revis showing that the commonest bacterium in the intestine of man, known as "bacillus coli," can be completely altered both as to its appearance and chemical activity by cultivating it outside the body in a broth to which a small quantity of an organic chemical compound known as malachite green had been added.

The effect of temperature and of light on particular kinds of bacteria, as well as of the presence of various chemical substances in the cultivation, have been made the subject of experiment during the past twenty years, but has not advanced very far. Hence the experiments made by Madame Victor Henri on the action of the ultra violet rays of a mercurial vapor lamp in modifying the mode and form of growth of the anthrax bacillus and its power of setting up the recognised symptoms of the disease known as anthrax are a welcome contribution to the general inquiry.

* The Daily Telegraph.



The gigantic rock folds in the Canadian Rocky Mountains sculptured by ice

The Origin of the Rocky Mountains*

As Told by Evidence Gathered by the Geological Survey of Canada

By S J Schofield

The elevated and mountainous tract which borders the western portion of North America is made up of a number of parallel mountain systems which trend northwest and southeast and hence parallel in a general way the corresponding Pacific coast line This tract known as the North American Cordillera has a width of four hundred miles in southern British Columbia

In an endeavor to describe the origin of the Rocky Mountains it may be well to precede the discussion by a general analysis of the North American Cordillera in Canada This has been admirably done by Prof R A Daly whose monumental work on the geology of these mountains has just been published The basis for the classification of the Cordillera is the great topographic or geographic breaks which cut it up into distinct mountain systems These geographic breaks are expressed in the form of longitudinal valleys which are remarkable features of the Cordillera and as far as present knowledge goes they coincide with the great structural breaks on which a genetic classification of mountains should be based

On approaching the Cordillera from the east the first range of the Rocky Mountain system rises from the monotonous plains in a long abrupt line of serrated peaks flanked at the base by a low range of foothills This system extends from Montana to the Arctic Ocean in the form of an elongated chain composed of three major segments arranged in echelon in which each successive northern segment is as it were stepped to the west Each segment is composed essentially of a remarkable system of parallel ridges, whose strike corresponds to the general trend of the main range The average width of the Rocky Mountain system in Southern British Columbia and Alberta is about sixty miles while at the Liard River it apparently loses its regularity and importance only to again assume the same character farther north In British Columbia and Alberta many peaks exceed 10 000 feet while the average elevation ranges between 8 000 and 9 000 feet.

On the west of the Rocky Mountain system occurs the Great Rocky Mountain trench a continuous geographic break recognized from Montana as far north as Alaska crossing the international boundary line in the vicinity of Dawson In the southern part of the Cordillera in Canada the Purcell Range—an elliptical shaped mass of rugged mountains occurs west of the Rocky Mountain trench Separating the Purcell system on the east from the Selkirk Range on the west is the Purcell trench in which occur Kootenay River and Kootenay Lake West of the Selkirk Range and separated from it by the Selkirk valley comes the Columbia system The last three systems the Purcell Selkirk and Columbia trend very close to north and south and hence are terminated to the north by the Rocky Mountain system which trending northwest southeast, cuts them off The Columbia Range gradually passes into the Interior Plateaus characterised by low rounded hills and plateau like upland stretches having a mean elevation of 3 800 feet above sea level This is succeeded to the west by the Coast Range which parallels the Pacific coast hence trending in a northwest south east direction The descent into the Pacific is precipitous and many deep fiords mark its contact. The most westerly subdivision of the Cordillera is the Vancouver Range constituted by Vancouver Island and the Queen Charlotte Islands The southern extension of this island festoon is the Olympic Range of Oregon

DISTRIBUTION OF ROCKS

For the purpose of description the Canadian Cordillera can be grouped into two basins of sedimentation a Pacific basin extending from the Columbia system to the Pacific Ocean and an Eastern basin covering the area from the Columbia system to and including part of the Great Plains These basins geologically can be considered as units in a genetic sense

The Columbia Range consists in great part of ancient gneisses and schists the oldest rocks in the Cordillera These rocks formed at one time the old land mass which extended in a northwest southeast direction from Central America to the Arctic Ocean The greater part of this old land is buried under recent deposits or has been destroyed by the invasion of vast quantities of molten rock. The majority of these gneisses and schists are of sedimentary or waterlain origin and hence must have been derived from a still more ancient land now unknown and shrouded in mystery To the east and west of this old land lay basins in which sediments derived from it by agents of degradation accumulated in vast quantities, for the most part, on an ocean floor

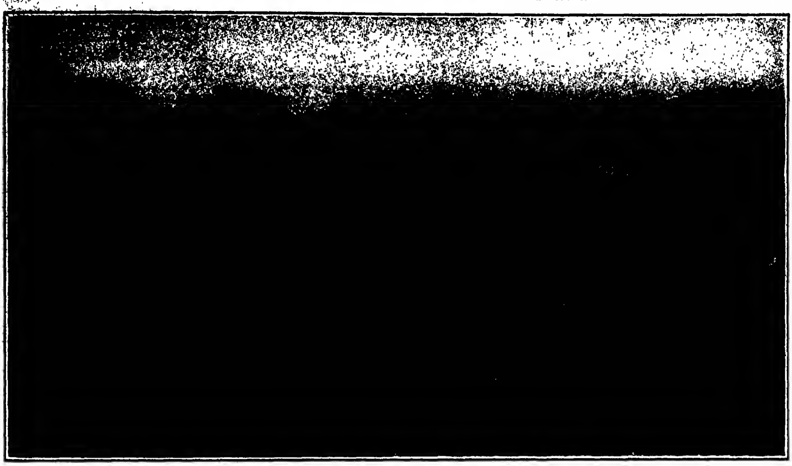
The Eastern basin, or geosynclinal, which forms the subject of this article, includes the area now occupied by the Selkirk Purcell, and Rocky Mountain systems. The Selkirk and Purcell ranges, with a geological history similar to that of the Columbia Range consist in great part of bedded rocks of pre Cambrian age intruded by masses of igneous rocks of the granite family The Rocky Mountain system the youngest member of the Cordillera is composed almost entirely of bedded rocks ranging from early Palaeozoic to late Cretaceous while the Great Plains are underlain at the surface by deposits of Cretaceous and of Tertiary age

Deposits of the last geological epoch the Pleistocene or Glacial period are scattered sporadically over the entire Cordillera

BUILDING OF THE PURCELLS

If we could stand on the ancient land in the neighborhood of the Columbia range in pre Cambrian time to the west could be seen a rolling and monotonous landscape of moderate relief while to the east, as far as eye could see a shallow sea in which was being deposited sand and mud derived from the gradual wearing away of the old land by atmospheric agencies and by running water That this sea was shallow and remained shallow till Cambrian time is evidenced by the ripple marks, mud cracks rill marks, and the casts of salt crystals now preserved in these hardened muds At the dawn of the Cambrian period this ancient sea became greatly enlarged and mingled its waters with those of the ocean This mingling permitted the life which inhabited the ocean to invade the shallow continental sea, for it is in these deposits that we find for the first time definite fossil remains in the form of trilobites brachiopods and marine worms. After this period the waters in the sea gradually deepened and marine invertebrate life abounded This is shown by the presence of limestones containing abundant remains brachiopods corals, and lamellibranchs in the Devonian and Carboniferous formations of the Rocky Mountains. During Jurassic time represented by the deposition of marine, carbonaceous muds, the first forecasts of a great mountain building period were registered During the latter part of the Jurassic, or early Cretaceous the Purcell Mountains were built. They consist of immense folds of stratified rocks forming typically folded mountains strongly resembling the Juras of Europe and the Appalachians of the Eastern United States. The area affected by this folding is represented on our modern maps as constituting the land as far east as the Kootenay-Columbia valley or Rocky Mountain trench. It was in the neighborhood of this trench that the western shore line of the [illegible]

* From Science Conspectus



Looking south along the range. Note the steep eastern and the gentle western slopes.

stood after the Jurassic Revolution. It had been shifted from the Columbia Range as far east as the western part of what is now represented by the Rocky Mountains.

THE ORIGIN OF THE ROCKY MOUNTAIN SYSTEM.

After the building of the Jurassic or early Cretaceous Mountains, they were at once subject to destruction by the agencies of erosion. The results of this erosion can be seen in the Cretaceous strata of the Rocky Mountain system. From a study of these strata, which for the most part are composed of conglomerates (water-worn pebbles) and carbonaceous shales (hardened muds) with which are associated many seams of coal and impressions of fossil plants, it may be concluded that at certain times the Cretaceous sea was shallow enough to have a dense jungle growth thrive upon its vast deltas formed from the material derived from the destruction of the Jurassic mountain ranges (Purcell and Selkirk) to the west. Sedimentation continued throughout the Cretaceous until sufficient stress had accumulated locally in this part of the earth's crust for the generation of another great mountain system, the Rocky Mountain system proper. For the formation of this great thickness of Cretaceous strata, the Purcell and Selkirk ranges were worn down to a low rolling landscape over which the meandering streams wandered sluggishly. This landscape, in technical language, is called a peneplain, and since it was formed during Cretaceous time, a Cretaceous peneplain.

At the close of the Cretaceous or in early Tertiary, the Rocky Mountains were formed. The earth's crust in this region was raised first in a series of gigantic folds with their longer axes trending northwest-southeast or parallel to the Pacific coast. In the eastern part of the range blocks of the crust were pushed up and carried bodily over the surface for a distance, in the case of the most eastern blocks seen east of Banff, of eight miles. Thus the Rocky Mountain system is a series of parallel ridges with steep faces to the east and gentle slopes to the west, and, in a view from one of the higher peaks, strongly resembles the parallel waves of the sea as they approach the shore. This simile is made more striking by the presence of the snow and ice on the northeastern slopes of the peaks in strong contrast to the deep green coloration of the forest covered valleys. In the picture the snow and ice sparkling in the sun represents the foam on the waves and the green forest, the cool depths of the ocean.

GNAWING OUT THE VALLEYS.

The initiation of a mountain chain by the folding of any portion of the earth's crust marks the beginning of its destruction. Rain descending on this elevated portion collects into streams which rapidly, in a young mountain range, gnaws for itself a valley in the folded strata. This first ridge probably will form the axis of the range. The next ridge which rises will be the result of a [illegible] tendency. The outgoing stream endeavors to maintain its course to the sea across the rising ridge, which offers a barrier to its progress. From an examination of the transverse streams of the Rocky Mountains we see the victory invariably rested with the streams which now cut through the folds and fault blocks. These through-going valleys, making it possible for the trans-continental trains to reach the Pacific, have become the highways of commerce and travel. Such valleys are occupied by the Crowsnest Branch and the main lines of the Canadian Pacific and the Grand Trunk Pacific Railways.

These streams are termed antecedent streams since they kept their course in spite of the barriers raised (by the mountain uplift) against their progress. The longitudinal streams, on the other hand, occupy weak portions of the mountain area. In the Rocky Mountains they occur in areas of Cretaceous rocks which, being composed of soft shales, sandstones and conglomerates, are more easily eroded than the Devono-Carboniferous limestone on either side. These streams, called subsequent streams, since they are initiated subsequent to the mountain building, are tributary to the through-going or antecedent streams. The position of the valleys in the Rocky Mountains, in contrast to that of the Purcell Range to the west, depends entirely upon the structure of the mountains, that is, the drainage is impressed concordant with the folding and faulting of the underlying bedded rocks and hence the valleys belong to one cycle of erosion. In contrast to this, the drainage of Purcell Range is entirely independent of structure and its history can be referred to two cycles. In the first, during Cretaceous time, it was worn down to a peneplain, then uplifted concomitantly with the formation of the Rocky Mountain system. This uplift rejuvenated the streams, which again eroded out the present valleys which can be referred to the second or Tertiary cycle of erosion.

SCULPTURING OF THE MOUNTAINS BY GLACIERS.

The final molding of the Rocky Mountains into their present form is due to the erosive action of ice. An examination of any area within these mountains would show that the heads of nearly all the streams terminate in a beautiful lake or tarn nestling in a rock basin. The basins are called cirques and owe their origin to the work of snow and ice. The configuration of this mountain tract previous to the Glacial period was naturally marked by inequalities in the upland stretches and in these inequalities snow would collect which, on the arrival of the Glacial period, would not completely melt during the summer months and would continue to collect until, with the precipitation in the winter far exceeding evaporation in the summer, the collection of ice would slowly move down the slopes into the valleys. The inequalities which would be filled with snow would gradually enlarge by the movement of the water underneath the snow and even by the snow itself as it crept slowly down the slope. With increasing diameter these depressions would be occupied first by a permanent snowfield and finally by the névé of a glacier. Plucking action along the bergschrund would now rapidly push erosion headward. This action is well described by D. W. Johnson[1], who descended 150 feet into a bergschrund in a glacier in the Sierra Nevada. "It was in all stages of displacement and dislodgement, some blocks having fallen to the bottom, others bridging the narrow chasm and others frozen in the névé. Clear ice had formed in the fissures of the cliff, it hung down in great stalactites, had accumulated in stalagmitic masses on the floor." Here he states that for a considerable part of the year there would be "a daily alternation of freezing and thawing. Thus a cliff would be rapidly undermined and carried back into the mountain slope, so that before long the glacier would nestle in the shelter of its own making. The ice grips like forceps any loose or projecting fragment in its rocky bed, wrenches it from its place and carries it away. . . . as the cirques receded, only a narrow neck would be left between them, which would ultimately be cut down into a gap or col. Thus a region of deep valleys, with precipitous sides and heads, of sharp ridges and of more or less isolated peaks, is substituted for a rather monotonous, if lofty, highland."

From the above description it can be seen that the detailed beauty of the Rocky Mountain system with its castellated crags, horns, cols, aretes, and cirques, is not due to the forms originating with the building of the mountain ranges: this merely places the foundation for the subsequent superstructure which is created in its main outlines by the erosion of running water, while the final decorations are furnished by the artistic touch of snow and moving ice.

[1] D. W. Johnson; Science, new series, Vol. 9, 1899, p. 106.

Explosion of an Electric Transformer

THE explosion of a large electric transformer in South Africa appears to have developed a new fact that was not before known. In taking down the transformer for repairs the workmen proceeded to drain the expansion tank located above the transformer of the oil it contained, and before doing so a workman held a lighted match over a sight hole in the tank, when a severe explosion occurred that either killed or severely burned every man present, besides setting fire to everything inflammable in the transformer chamber. As the oil in the tank was not above 34 deg. Cent., and its flash point was 140 degrees, the gas that caused the explosion could not have been oil vapor, and experiments were instituted using extra high tension discharges under transformer oil. Samples of the resulting gases were collected, which, on analysis, proved to contain at least 62 per cent hydrogen. It is evident from this experience that great care should be exercised not to allow a naked light near transformer oil tanks or oil switches until they have been thoroughly ventilated.

Protection from Earthquakes*

Principles of Location and Methods of Construction Found Desirable

By Th. Moreux

Although the definite prediction of earthquakes still presents serious difficulties, we have, at least, learned the location of the seismic regions of the globe, and, in general, the degree of instability of the soil therein. Hence arises the capital question: Must seismic regions be abandoned, or are there means of ensuring the safety of their inhabitants? The abandonment of such countries is, for material reasons, impracticable, but those who dwell in them should give heed to the facts stated below.

CHOICE OF A BUILDING SITE.

The location of a building in a region subject to earthquakes is by no means a matter of indifference, for within such regions some districts always suffer more severe effects from seismic shocks than others. Thus, during the great Lisbon earthquake of 1755 the lower portions of the town, built on alluvial or uncompacted tertiary soil, were devastated while the higher quarters, built on basalt, withstood the shocks quite well. At Aix-la-Chapelle, in 1877 and 1878, destructive effects were confined to the part of the town built on a loosely compacted chalk, while the quarter built on limestone did not suffer. At Tokio the higher part of the town, built on the rock, almost always suffers much less from earthquakes than the lower town, the soil of which is alluvial. Many other illustrations could be cited. Some exceptional cases admit of special explanations.

Soils consisting of alluvium or débris, *when they occur in a very thick layer*, offer an extremely favorable site for buildings. The reason is that they are very poor transmitters of seismic waves, which are propagated in them with as much difficulty as sound-waves in sawdust. This is true of alluvial strata whether lying underground or at the surface. Examples are found in the plains of northern Germany, the Russian steppes, the llanos and pampas of South America, and the prairies of Arkansas, where seismic shocks are almost unknown. These regions are, for the most part, characterized by the great thickness of their alluvial deposits.

On the other hand, if such strata are shallow, considerable movement will be felt. This apparent contradiction may be explained on the analogy of a mass of sand into which a cannon is fired, as in certain artillery tests; if the mass is thick it deadens the impact, while a small layer or pile of sand is scattered in all directions. Hence one should especially avoid placing a building on a thin layer of relatively loose soil overlaying a thick and solid stratum.

Generally speaking, anything which interrupts the homogeneity of the ground tends to increase the shocks transmitted. Location should, therefore, be avoided at the junction of two strata of very different material, as well as the vicinity of geological faults and the brows of cliffs and ridges. In such locations an earthquake produces a phenomenon analogous to that which is seen when a violent blow is given to the first of a series of billiard balls, lying in contact with one another; the shock is transmitted by the intermediate balls, but only the one at the other end of the row is set in motion. Villages and buildings perched on the side or crest of steep hills suffer severely in earthquakes; the superficial layers of the earth play the same rôle as the final billiard ball just mentioned; even solid rocks may be thus cracked or broken into fragments at the surface; long crevasses are formed parallel with the steep face of cliffs; and sooner or later landslips occur. In a similar manner, the banks of rivers may collapse, carrying down and destroying houses, roads, and cultivated fields. These facts illustrate the danger incurred in installing buildings, conduits, roads, or railways along steep escarpments in countries subject to earthquakes. The same considerations apply to railway embankments; they need to be flanked by very strong constructions.

To summarize—in "earthquake countries," or even regions of ordinary seismicity, it is advisable to avoid placing houses on lofty elevations, where the amplitude of seismic vibrations will reach a maximum, or on the slopes of hills and mountains. Plains and broad valleys offer a preferable location. Between two locations on loose soil, one should choose that in which the loose soil has the greater depth. In all cases one should take warning from the history of previous earthquakes; it should never be forgotten that it is dangerous to build on the spot where a well-constructed building has been destroyed by an earthquake, since like causes will again produce like effects.

FOUNDATIONS.

The question of foundations is very important. Shall we build on deep foundations, extending, if possible down to the subjacent rock? or shall we eliminate foundations altogether, and permit the building to rest directly on the ground? The experience of earthquake countries furnishes the answer.

It has long been known that seismic vibrations have a much greater amplitude—in fact, about twice as great—at the surface of the ground than at the bottom of an excavation some 10 feet in depth. It is therefore necessary to sink the foundations as deep as possible, and also to isolate them from the surrounding soil, in order to free them from the vibrations of largest amplitude. Thus at Tokyo several large buildings of the Imperial University resisted perfectly a number of violent earthquakes when neighboring buildings, constructed of equally solid masonry, were partly destroyed; investigation proved the different effects to be due to the fact that the buildings of the university had much deeper foundations than the others.

Whenever possible, the foundations should rest directly on the underlying rock. The regulations drawn up for the island of Ischia after the disaster of 1883 provided for cases in which the rock lay too far below the surface to be reached; under such circumstances the building was to be erected on a masonry or concrete platform two feet thick for a one-story building and 4 feet thick for a two-story building; and the platform was to extend from 3 to 5 feet beyond the base of the building. In Manila the regulations provide that the foundations shall be strong enough to support twice the weight actually placed upon them. Whenever the underlying ground is unfavorable, the foundation of a building should form a united whole, so that the different parts of the superstructure may be subjected to the same shocks. Cases are common in which disastrous effects have been due to the fact that various parts of a structure did not undergo simultaneous vibrations. Many remarkable examples are found in the history of railway bridges, as recorded in the reports of Omori and others.

Regulations in force in countries subject to earthquakes permit the construction of cellars, and even of vaulted ceilings therein; but these ceilings must be "full centered." Above the ground vaulting is always forbidden, as it tends to spread the walls.

Milne also mentions a method of making the building independent of the ground on which it rests, which consists of placing it either on cast iron balls or on two sets of iron rollers at right angles to each other, these resting on a floor of concrete. Such arrangements would, however, be suitable only for very small buildings and would provide no immunity from vertical displacements.

It has often been noticed that crevices and especially caverns in the ground oppose an obstacle to seismic movements. In Santo Domingo deep excavations are made in the ground near houses to insure the stability of the latter. Pliny believed that Rome was protected from earthquakes by the Catacombs. On the other hand, it should be remembered that subterranean galleries necessarily diminish the strength of the ground and introduce a new danger which is certainly not compensated by their diminished capacity for transmitting seismic waves.

Practically, in regions where earthquakes are not of extreme violence, it will suffice to build foundations very deep and at least twice as thick as they are ordinarily built elsewhere. If there is a vaulted cellar, its roof should be full-centered. Only the best and strongest materials should be used. Foundation walls increasing in thickness with depth are sometimes employed in Japan, and can be recommended.

WALLS AND CHIMNEYS.

In most cases it is the highest buildings which suffer most severely. The reason is obvious; if we shake a young tree by grasping its base, we shall see that the highest branches undergo the most violent movement.

Various regulations as to the height of buildings and the number of stories have been promulgated in earthquake countries. In Manila only the walls of the ground floor may be of masonry; the second story must be of wood. In order to diminish the weight of material the use of hollow bricks is to be recommended.

In an ordinary house consisting of four walls forming a rectangle, it is important to prevent the separation of the walls at their angles of junction, and various systems of iron frames and tie-beams built into the masonry have been proposed to prevent such separation. It is certain that a house forming an absolutely rigid and indeformable box would be the ideal plan, but it would be extremely difficult of realization, especially in the case of large buildings. Iron built into masonry does not form a homogeneous whole. Walls and floors bound together with metal tie-beams may not vibrate in unison, and this is one of the most serious causes of disaster.

In Japan the light houses of wood and paper suffer comparatively little injury, and the damage would be still less if the walls were fastened together at the bottom with wooden girders. In Santorin the people from time immemorial constructed their houses in the form of a monolithic box, without bottom, simply resting on top of the ground. They are built of a kind of cement consisting of lime and crushed lava. Openings are reduced to a minimum, and the vaulting is very thick. The roofs crack without falling.

In recent years the use of re-enforced concrete has been widely recommended, and it is certain that in this form of construction the problems seem to be solved, since all parts of the building—walls, ceilings and floors—are tied together. Re-enforced concrete has been much used in re-building San Francisco. This mode of construction is still so new that we cannot pronounce definitely in its favor, but it is highly probable that buildings thus constructed would merely fracture or crumble more or less without falling, and this would be a real advantage to their occupants.[1]

The openings in the walls are points of weakness and are often a cause of ruin. In Italy the regulations require that these shall be placed vertically one above the other. This is an unwise rule; a wall in which all the windows are in line vertically is virtually divided up into several parts and loses all power of resisting shocks. Milne, on the contrary, recommends that no two windows be in the same vertical line, regardless of the number of stories. The doors and windows should, moreover, be placed at some distance from the angles of buildings.

The shape of the openings is also of much importance. After the earthquake of 1885 in Tokyo, a careful examination was made of the European buildings in the Ginza quarter, and it was found that in all cases the windows in which the arches sprang sharply from their abutments had cracks running from the angles, while in those in which the arches curved out gently from the abutments there were no cracks, except in cases where the arches supported balconies. This example clearly indicates that only round-arched windows are admissible in a masonry wall. Stone balconies should be rigidly prohibited, as under shock they crack the walls or may fall upon the heads of people rushing from their houses. The same remarks apply to ornamental stone cornices and balustrades, and to heavy ornaments on ceilings.

Stairways should, as far as possible, be independent of the walls, as otherwise they play the same destructive rôle as balconies. Chimneys have been the cause of many accidents. At Charleston, in the earthquake of 1886, out of 14,000 chimneys, 13,200 fell. It is a good rule not to let them extend above the roof; they can be prolonged upward by means of a light sheet-iron pipe supported by somewhat slack guy-wires. The body of the chimney should not be built into the wall, which it would tend to crack in an earthquake, but may be placed in contact with it.

As to masonry materials, these should be of the very best quality; and in the superstructure preference should be given to materials combining a maximum of resistance with a minimum of weight. In very many cases where houses crumble at the first shock of an earthquake, the blame may be laid entirely on the inferior quality of the material, or a defective assemblage of stones and brick; in short, upon the neglect of the most elementary principles of construction.

ROOFS AND JOISTS.

However, in the course of my investigations in Provence after the earthquake of 1909 I observed many cases in which very solidly constructed buildings had collapsed like the rest. The reason was obvious. When the walls first oscillated under the action of the seismic wave, the joists were pulled out of their sockets and the ceilings descended en bloc after the shock, the walls which, in virtue of their elasticity, tended to regain their equilibrium, were obliged to give way to the wedge-like pressure of these beams. This effect was due to the fact that, as a rule, joists are merely supported

* Condensed translation of a chapter in his "Les tremblements de terre," 2nd ed., Paris, 1909.

[1] There was only one large building of re-enforced concrete in San Francisco at the time of the earthquake of 1906, [illegible] this was unfinished. It resisted both the earthquake and the fire satisfactorily. During the recent great earthquake in Italy it is said that, in some places, the only buildings that remained standing were those of re-enforced concrete.

on the inner border of the walls, instead of passing entirely through the latter Hence, in an earthquake, the various stories fall on top of one another inside the walls. In order to prevent this, the beams should extend through the walls and project a foot or more on the outside, forming a sort of corbeling or balcony, such as we see in many mediaeval houses.

Analogous principles should guide us in the construction of the roof It is easy to see that if the latter is very heavy, when an earthquake occurs the whole roof, in virtue of its inertia, will behave like the steady mass of a seismograph, i e, it will not participate in the movement of the building beneath it The result is that either the walls, in their oscillation will slip away from the beams supporting the roof permitting the latter to fall and carry the edifice with it, or the walls will have a tendency to break halfway up, owing to the fact that their upper portions, which are fastened to the roof do not vibrate in unison with the lower portions Hence the roof should by all means, be made as light as possible, and it will be necessary to abandon conventional building methods in order to effect this

The necessity of doing so will appear from the following figures Roofing of flat Burgundy tile for a building 10 by 5 meters (33 by 16 feet) would weigh 9 900 pounds If we use the lighter mechanical tile the weight will still be between 3,500 and 5,000 pounds These figures do not include the weight of the woodwork of the roof A slate roof, though lighter than tile would weigh 2 200 pounds, not including the woodwork Evidently with any of these materials we place an enormous weight on top of our building, and it will not be surprising if seismic vibrations cause a rupture between walls and roof

The remedy has been sought in zinc or galvanized iron, either of which weighs about one-eight as much as flat tiles The weight of such a roof of the above dimensions, would not exceed 1 300 pounds but its use has serious structural disadvantages A metal roof is subject to deformations due to heat and cold and the greatest precautions must be taken to make it water-tight Moreover these roofs are very hot in summer and cold in winter, so that one or two false ceilings must be used under them and this means added weight and expense

I sought for a long time a roofing material that was free from all these disadvantages In twice building my observatory I needed a covering for the dome and the roof that would combine lightness and solidity, and I found these conditions realized in a material which although not new is less well known than it deserves to be It is called 'ruberoid and is a sort of woolen felt, impregnated with a simple waterproofing composition It comes in long rolls and is equally suitable for flat and sloping roofs Most of the new wooden buildings at Messina erected since the great earthquake are covered with this material which is not affected by variations of temperature

A covering of 'ruberoid' for a roof of the dimensions mentioned above weighs just 209 pounds i e, about 1/45 as much as one of ordinary tile and 1/20 as much as one of mechanical tile When I add that, by building the roof flat, we do away with the heavy timbering needed in a sloped roof, it will be seen that the use of this material is plainly indicated for earthquake countries

The use of a horizontal roof not only ensures lightness but also obviates one of the common dangers of earthquakes, when many persons are killed or injured by the fall of tiles and slates from sloping roofs Whatever covering material is adopted, the joists of the roof should extend from 1½ to 2 feet beyond the walls

CONCLUSIONS

The following is a summary of the essential facts deduced from the above discussion

Having chosen a suitable site, we may adopt one of two different plans, according to whether we propose to erect a large and costly building or a modest dwelling In the former case we must endeavor to secure great rigidity by the use of relatively heavy material The foundations will be thick and deep; the masonry very carefully laid, and the walls securely joined at the angles If the cellar is vaulted, the vaulting must be full-centered and very thick There should only be two stories, and the joists supporting the second must at least run through the whole thickness of the walls, to prevent them from being pulled loose The openings will be planned in accordance with what has been said above They should be rather narrow, and round-arched A light roof, with joists extending beyond the walls, is essential. In order to lighten the upper story the latter might be constructed of hollow bricks Stout inside walls will add much to the solidity and rigidity of the building.

In the case of the ordinary dwelling, flexibility should be preferred to rigidity, and we should seek to construct a house analogous to a wicker basket. A skeleton of wood or iron, very securely tied together, will always [illegible] especially if the building has but [illegible] walls presents serious [illegible] and less protection from extremes of temperature a better plan would be to adopt the system of 'barrack' construction popular in Italy According to this plan a frame of wood or metal is filled up with as light walls as possible consisting of hollow bricks or other material of slight density

Two important principles should never be forgotten in any form of earthquake construction viz avoid weight of material unless accompanied by a corresponding degree of solidity and seek to unite to lightness and strength a certain amount of elasticity

[Further information on the subject of earthquake-proof construction will be found in the following works J Milne and others Construction in Earthquake Countries Trans Seismological Soc Japan volume 14 J Milne Seismology London 1898 chapter viii-ix Montessus de Ballore La sismologie moderne Paris 1911 chapter xx U S Geological Survey The San Francisco Earthquake and Fire and their Effects on Structures and Structural Materials Washington 1907 Also numerous reports in the Publications of the Earthquake Investigation Committee in Foreign Languages Tokyo —EDITOR]

The Causes of Solar Heat*

By A. Veronnet

THREE different hypotheses have been advanced to explain how the sun has for ages been emitting substantially the same quantity of heat via by chemical reaction by intra atomic energy (such as is exhibited by radium) and by the attraction of gravitation Some precise calculations based upon recent data seem to indicate that the last theory advanced by Helmholtz is the one that is most tenable

The sun emits about 5 10^{33} calories per annum and its mass is 2 10^{33} grammes Even if the maximum calorific capacity be placed at 1 its temperature would fall by at least 2 5 deg Cent (4 5 deg Fahr) each year But the average temperature of the earth measured in degrees absolute is directly proportionate to the temperature of the sun Let us take 6 000 degrees and 293 degrees absolute (20 deg Cent) as the average temperatures for sun and earth It may be calculated that the earth's temperature on the surface would fall to 0 deg Cent (32 deg Fahr) after the short period of 165 years if this heat is not in some way replenished.

Chemical Reaction—The condensation of vapors and the formation of chemical compounds can occur below only the critical or dissociation temperature which latter is very near 5 000 degrees or 6 000 degrees for heavy metals and refractory oxides Now no known chemical reaction can develop 5 000 calories per gramme (the maximum of 4 700 degrees is obtained by the combustion of lithium) The entire mass of the sun would then be able to supply through condensation or combustion at the most 5 000 × 2 10^{33} calories or sufficient heat for 2 000 years

Intra Atomic of Decomposition—This is much greater than the energy of combination but its effects are also much slower although it amounts to billions of calories per gramme It is admitted that all substances are subject to slow decomposition liberating this internal energy in the process but the phenomenon is perceptible only in the case of radioactive substances and is most pronounced for radium It is known from the latest calculations (table issued in *Le Radium* January 1914) that 1 gramme of radium liberates 132 calories per hour let us say 1 2 10^{6} calories per annum In order to account for the radiation of the sun it would be necessary to assume its radium content to be 4 2 10^{27} grammes or 2 grammes per metric ton which is a higher percentage than that of the richest known minerals.

But the activity of radium decreases with time and would be reduced by half after some 1 700 years (S Meyer Sitzb Wiss in Wien March 1914) and this quantity of radium could not maintain heat and life in the sun and earth for over 2 000 years unless it could be renewed It is true that uranium is transformed into radium the constant ratio between the two substances being about three tons uranium for one gramme radium after the calculations of Strutt, Eve Cove and Boltwood (the constancy of this ratio is however called in question by some calculations of Miss Ellen Gleditsch, *Comptes Rendus* volume cxlviii 1909 page 1451) According to these figures the whole mass of the sun would have to be composed of uranium in order to keep the necessary quantity of radium constant during a sufficient length of time

Besides, the alpha rays of radium may be projected from helium, at all events radium is transformed partially into helium and 1 gramme of radium supplies yearly 156 cubic millimeters of helium or 2 8 10^{-5} grammes, together with 1 2 10^{6} calories The production of 1 gramme of helium corresponds with a release of $1{,}2.10^{6} : 2{,}8.10^{-5} = 4{,}3.10^{10}$ calories. If we are able to estimate the quantity of radium in the solar atmosphere we can thus obtain the amount of heat which the radium contained in the sun has been supplying

It has been possible to determine the pressure on the surface of the sun or at least above the helium zone through the displacement of the lines of the reversing layer Buisson and Fabry (*Comptes Rendus* March 15th 1909) estimated this pressure at 4 to 6 atmospheres Jewell Humphreys and Mohler (*Astronomical Journal* volume iii page 139) place it at 2 to 7 atmospheres Evershed (Kodaikanal Observatory No 18 1910) calculate it to be as low as 0 13 atmosphere on an average Let us concede a maximum pressure of 10 atmospheres gravity on the sun being twenty-eight times as great as it is on the earth the whole atmosphere of the sun must have a mass of about 10 : 28 = 0 35 kilogramme per square centimeter (almost 5 pounds per square inch) that is to say 340 6 10^{20} = 2 10^{23} grammes Supposing it to consist entirely of helium it would correspond to the liberation of

$$2\ 10^{23} \times 4\ 3\ 10^{10} = 8\ 6\ 10^{33}\ \text{calories}$$

which represents heat enough for only 170 years. This is the maximum supply of radium.

Besides, the percentage of helium in the solar atmosphere is rather low as it does not give any black line in the spectrum and its absorption is not marked It is probable the above figure ought to be divided by 100 or 200 It must be concluded therefore that intra atomic energy cannot have noticeably intervened in the maintenance of solar heat

Gravitation—It has been suggested that meteorites dropping into the sun or the fragments of a comet may be responsible for solar heat But while the mass of sun would increase the time of revolution would decrease Taking into account Kepler's third law and the decrease in the amount of motion we easily obtain the formula M^2T = constant The oldest observations show that the year is decreasing by 0 53 second each century Attributing this variation solely to the increase of the mass of the sun and differentiating the foregoing formula we find 1 67 10^{20} grammes as the maximum annual increase The energy produced by a mass of 1 gramme falling on the surface of the sun may be calculated as equal to 2 10^{15} ergs and this increase in mass produces at the most 8 10^{28} calories per annum or four hundred times less than necessary for the maintenance of solar heat

Hence there is but one hypothesis left—that of the generation of heat by the contraction of the sun itself, and this alone can and must account for all the heat the sun is radiating This contraction could account for an amount of energy or work equal to twenty million times the amount of energy the sun is radiating every year at present This moreover is a maximum and it has been shown (*Comptes Rendus* February 9th and 23rd 1914) that, considering the fact that the radius and temperature of the sun were both greater in the past it must be admitted that radiation and loss of such heat required a little less than two million years. The sun in its present condition and life upon the earth can be traced back about two million years. The conclusion may therefore be drawn that the temperature upon the earth will not fall below 32 deg Fahr in less than two million years to come a period which will undoubtedly be prolonged by the fact that the earth is drawing nearer the sun

It is true that geologists claim one hundred million years and more to have been necessary for the formation of the geological strata But they are measuring erosion on the basis of the present causes acting with present intensity Erosion is caused by the heat of the sun which produces clouds and rain We have here a sort of heat engine and we know in such a case that the more powerful this engine is the greater the results The contraction of the sun allows us to dispose of an amount of heat equal at the maximum to twenty million times that which it is radiating at present per year and admitting that this heat is spent over two million years instead of twenty million we must multiply the power of erosion by 10 (see Hermann Hypotheses cosmogoniques modernes 1914 page 139) It can also be admitted that the product was multiplied by 10 making thus erosion work equal to that which would require two hundred million years the present rate and calculations of both geology and celestial mechanics will thus be made to agree.

* Translated for SCIENTIFIC AMERICAN SUPPLEMENT from Cosmos.

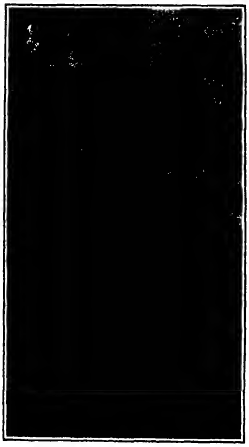
Electric Lighting on American Railways

THE statement was recently made that the number of cars on American railways lighted by electricity had increased from about 11 000 in 1911 to nearly 19 000 in 1914 a growth of 72 per cent The greatest part of this increase uses the storage battery and axle generator system while the head-end installations have increased but one third this amount Of the storage batteries there are in use about 260 000 lead battery cells and 32 000 of the nickel iron cells but this latter figure represents an increase of six times in the last two years

The Canon Ball Tree of Tropical America

The cannon ball tree (*Couroupita guianensis*) is one of the most curious trees in tropical America. It is so called because the fruit resembles a cannon ball. Although the tree is sometimes referred to in botanical literature as the bullet wood or nutmeg these names are almost never applied to it in the region where the tree grows. The French have named it *arbre à bombes*, *boulet de canon* and the popular German names are *kanonenballbaum* and *kanonenkubelbaum*.

The cannon ball tree may be said to be large but it does not vie in height and diameter with the majority



The cannon ball tree in flower

of other trees in the tropical forests. It seldom develops a long trunk which is rarely three feet in diameter four feet above the ground and only from ten to twenty feet to the first branches which are usually spreading or partly ascending forming a broad irregular or round depressed crown. While the tree often attains a total height of sixty to ninety feet in the forest, in the open it seldom grows as tall but its crown is more spreading.

The tree is confined largely to the low moist land skirting the rivers but it never occurs in great numbers even where the conditions are most favorable for its best development. One may travel for miles in the dense tropical jungle without seeing a single tree of this species. It is believed that the northern limit of its distribution is in the Republic of Panama where it has been reported by only a few botanists. During the recent biological survey of the Canal Zone a specimen of this species was discovered growing just south of the city of Panama and it appeared from the available data that its range of growth extends from this point in Panama southward and eastward to the mouth of the Amazon River. It is found on the island of Trinidad but it is more common to the low moist soil of the mainland especially in the Guianas.

Several beautiful trees are growing in the public parks in Port of Spain Trinidad and also in the botanical garden in Georgetown British Guiana and very few visitors to these cities who are interested in nature fail to see these curious trees. It is a rapid grower and quickly forms fine features as a specimen plant in a tropical garden. It suddenly drops its leaves in March and in a few days is again clothed in fully developed foliage of the richest green. The flowers are large abundant very curious in form pink in color and highly scented.

There is hardly another forest tree in the world that bears its fruit similar to that of the cannon ball tree. The fruit is a large woody globular pod about six or eight inches in diameter resembling a cannon ball. The shell or pericarp is thin smooth grayish brown or rusty colored, and has a circular scar near the center which marks the point where the calyx or outer floral envelope became detached from the young unripe fruit. The shell when opened at this scar and the pulp and seeds removed is often used in tropical America for domestic purposes as a calabash. The pulp which surrounds the seeds possesses an agreeable flavor, and when nearly ripe is often employed for making a refreshing drink in case of fever. This pulp contains sugar gum and malic, citric and tartaric acids. The over matured fruit possesses a very disagreeable odor which is remarkable for its penetrating and lasting properties. The seeds of which there are a great many in each fruit, are flat, circular and rather larger than a dime. They are imbedded in the pulp from which they are easily separated upon maturity. As will be seen in the accompanying illustrations the fruit is borne in clusters on the trunks and large lower branches, and not near the ends of the small branches or ultimate twigs as in other trees.

The Explosion of Kerosene Lamps*

Every little while we hear of the explosion of a kerosene lamp attended by serious injuries to persons who happen to be near. In the public mind there is something mysterious about these lamp explosions—something that calls for explanation. They are usually attributed to the poor grade of the oil or to some other cause unknown to the owner or user of the lamp or beyond his or her control. Various persons either in good faith or otherwise have tried to make capital out of the widespread feeling of distrust that the public has toward kerosene lamps. Some years ago for example there was a heavy demand for a certain bluish powder that was to be placed in the reservoir of the lamp and which was guaranteed to protect it against explosion. Of course most of the lamps that were protected by this powder did not explode but that was only because few lamps explode anyway. There is no reason whatever to suppose that the proportion of explosions was any less among the lamps "protected" in this way than among those that were not "protected."

There is nothing actually explosive about the *oil itself* whatever its grade may be. Explosions are due to the ignition of mixtures of *oil vapor* and air and they are more likely to occur when using a low grade oil than when using one of a higher grade because the low grade oil contains a larger proportion of light volatile hydrocarbons and it therefore gives off vapor more freely. But whether the oil be high grade or low grade its vapor will not explode unless it is mixed with air in a suitable proportion and fired by direct contact with a spark or a flame.

The quantity of oil vapor generated in the reservoir of the lamp depends upon the temperature of the reservoir as well as upon the nature of the oil—a high temperature causing a marked increase in the vaporization. It is therefore advisable to keep the temperature of the oil reservoir as low as practicable. To some extent this is a matter of design and it is almost impossible to prevent the reservoirs of metal lamps burning large quantities of oil from becoming heated to a temperature high enough to produce marked vaporization. All lamps should be kept as cool as their construction will permit however. For example they should not be allowed to stand on over or near hot stoves registers or radiators. They should also be kept as nearly full as practicable so that the space occupied by the oil vapor may be small.

If the upper part of the reservoir of a lamp is occupied by an inflammable mixture of oil vapor and air it is still not dangerous unless flame gets access to it. In fact, when a lamp explodes the trouble is far more likely to be with the lamp itself or with the way it is used than with the oil although prudence always indicates that the oil should be of the best quality obtainable, with a high flash point, so that any chance communication of flame will be unlikely to lead to serious results.

For flame to gain access to the interior of the reservoir there must be an opening of some kind through which it can pass. The opening may be due to the omission of the plug or cap from the filling aperture or it may be due to a break in the reservoir or to other causes. More often however the explosion takes place because the wick does not fit the lamp properly. If the wick is too small so that a considerable space is left on one side of it gas may escape in this way taking fire and carrying the flame down into the reservoir if the opening is big enough. This action may be assisted or precipitated by blowing down into the top of the lamp to put it out, or by the chilling action of a draft of cold air striking against the outer surface of the reservoir. If there is a considerable volume of mixed air and vapor in the reservoir in a highly heated condition, a sudden cold draft may cause it to contract quickly enough to draw the flame down into the reservoir, with an explosion as a result. Lest timid householders who may read this warning should be unnecessarily alarmed about the condition of their lamps, we desire to assure them that there is no danger of the kind described unless there is a plainly visible opening of considerable size down along one edge of the wick. The wick should be loose enough to work freely, for if it fits too tightly it will not turn up and down readily, and if it jams in its tube the oil will not draw up well, and the lamp will not burn properly.

By examining any properly-constructed kerosene lamp it will be seen that there is a small vent pipe, usually very much flattened extending upward through the burner in such a way as to put the interior of the reservoir in free communication with the space immediately adjacent to the flame. This tube is provided in order to equalize the pressure inside the lamp with that of the surrounding air of the room. This little tube should be kept free but care should be taken not to increase the size of it in any way. It is a well known fact that flame will not pass through very small openings, and the maker of the lamp knows just how large this vent pipe can be made and what shape to give it, so that it will fulfill its purpose without permitting the gas-mixture in the reservoir to take fire from the flame of the lamp. As the lamp leaves his factory the vent pipe is of a safe size but if it is enlarged to any considerable extent by thrusting things into it when cleaning the lamp it may become a source of danger.

Finally the operation of filling should never be carried out while the lamp is burning nor while it is standing near any lighted lamp or gas jet or near a stove with a fire in it.

If the various points that we have mentioned receive careful attention there need be no fear of a lamp explosion except as the result of dropping the lamp or subjecting it to other rough and unreasonable usage for which it was never designed.

* The Preacher's Standard.

New Three-phase Motors

One of the recent ironclad three-phase motors of Swiss make embodies some original features, and is the result of careful study in order to produce a substantial motor for certain classes of work. What is desired here is a nearly or all inclosed motor of moderate size with forced draught so as to allow of its use in damp places. For very wet localities or those containing acid fumes, the motor is entirely inclosed. An air fan at one end of the armature creates a suction through one leg from the flow beneath and the air traverses the motor and descends through the other leg of the motor. An original idea lies in the working of the starting resistance. This consists of a disk resistance coil on the motor shaft next the air fan and from here run six copper rods clear through the armature to the other side. A large copper ring slides on all six rods, which have an equal length, so that sliding the ring along the rods by a hand wheel mechanism short-circuits the rods successively. In this way no slip rings or brushes are needed. An outside hand wheel operates the sliding of the ring which of course rotates with the armature, and the same mechanism serves to throw the main switch of the motor.

The Gas from Blast Furnaces—I*

Its Cleaning and Utilization

By J. E. Johnson, Jr.

The realization of the great heating value of the top gases of the blast furnace was very slow in taking useful shape. For centuries, furnaces ran with their tops wide open, discharging the gas into the air, with which it united in a great column of flame, visible for miles by night, even in the smaller furnaces of that early day.

Even after the invention of the steam engine, the possibilities of blowing furnaces by steam power were not practically realized for several decades and furnaces continued to be located primarily with reference to a suitable water power for blowing. In the same way after the invention of the hot-blast in the third decade of the nineteenth century the stoves were not at first heated by gas from the furnace, but were independently fired with coal.

Later a small chamber filled with iron pipes was built over the top of the furnace and the flame from the open top passed up through this, heating the blast which passed through the pipes. Still later flues were built into the brick work near the top, but just below the stock line and connected with a powerful chimney whose base was approximately level with the top of the furnace; this chimney drew some of the gas from the furnace, naturally much mixed with air drawn in from above, and the mixture burnt on its passage from the furnace top through the boilers and stoves to the chimney.

The final step was taken by closing the top of the furnace with a huge conical valve called the "bell" and forcing the gas by the pressure from below out through the flues into a pipe leading down to the ground level, where the stoves, boilers and stacks were located. This pipe early received and still retains the name of the "down-comer."

These top gases in Lake ore practice contain about 50 per cent of the total thermal value of the fuel charged. In districts where leaner ores are used and more fuel is consequently required per ton of iron the gas is correspondingly richer and contains a proportionately larger percentage of the thermal value of the fuel. In Lake ore practice an average analysis is about as follows: carbon monoxide 25½ per cent, hydrogen 3 per cent, carbon dioxide 12½ per cent, nitrogen 59 per cent. The thermal value comes entirely from the two former components.

The hydrogen comes partly from the moisture in the blast which is dissociated in the hearth, and partly from the moisture of the charge which is decomposed in the upper levels of the furnace. This gas under standard conditions of 32 deg. Fahr. and 30 inches of mercury contains from 94 to 102 British thermal units per cubic foot and has a specific heat of about 0.02 per cubic foot so that it contains about 2 British thermal units of sensible heat for each 100 deg. Fahr. above that temperature.

This gas is then somewhat more than half as high in heating value per cubic foot as ordinary producer gas. This, with the enormous volume produced (some 140,000 cubic feet per ton of iron in good practice and more where the practice is poorer), gives it enormous commercial value, so great in fact as to equal a considerable percentage of that of the pig-iron itself.

This gas having been in intimate contact with the charge in its course up through the furnace, and having carried off all the moisture of the charge not dissociated necessarily contains much moisture and picks up much fine dust from all the different components of the charge. It also carries a fume consisting of solids volatilized in the hearth of the furnace which sublime into the solid state, but in the form of an impalpable powder, as the gas cools in its progress toward the furnace top.

It is this fume that gives the gas its characteristic appearance, so that an experienced furnaceman can tell more quickly by looking at the gas discharging from the boiler and stove stacks than by any other way if his furnace is working "hot" or "cold," since a relatively few degrees drop in hearth temperature make a great difference in the amount and appearance of the fume thrown off.

The composition of this fume will be treated more at length in a subsequent article; for the present it is only necessary to say that it consists mainly of silica, alumina, lime, potash from the ash of the coke, and iron, and in case the charge contains much manganese, this element is present in the fume to a great extent, changing the white color of the fume of a good working furnace on ordinary iron to a light yellow when running [illegible] and to a dark yellow or brown when running [illegible].

* [illegible] Metallurgical and Chemical Engineering.

In the early days of slow driving the velocity of the gas current through the furnace was small and the quantity of fine ore in the charge was almost negligible in comparison with the quantity of fine ore used to-day, which runs from 50 to 100 per cent Mesabi in the majority of American practice.

Under those conditions a single, comparatively small outlet at one side of the furnace top was sufficient and the quantity of dust carried by the gas was extremely small, therefore a single pipe of moderate size running straight or almost straight down and branching directly off to the stoves and boilers was all that was necessary to handle the gas. This constituted but a small, almost an insignificant fraction of the plant as a whole. Conditions at the present are vastly different from this in three respects:

First, the velocity of the gas through the furnace is several times greater than it was in those early days and the carrying power of the fluid current increases at an enormously rapid rate with an increase in velocity. I have seen the statement that this increase was as the seventh power, which would mean that doubling the velocity would increase the quantity of material carried 128 times. Whether this be true or not it is certain that the rate of increase in carrying power is extremely high.

Second, the ore used instead of being practically all hand-prepared lump consists very largely of fines, much of which is capable of passing through a 100-mesh sieve.

Third, we have come to realize the enormous cost of attempting to utilize gas in its dirty condition for stoves and boilers, even leaving out of consideration gas engines, which require gas cleaner than the air we breathe for their successful operation.

These three causes have had an enormous effect on the gas-handling system of the furnace which has in recent years become one of the largest and most conspicuous features of the whole blast furnace plant.

THE OUTLETS FROM THE FURNACE TOP.

From the time of the closed top or soon thereafter, some furnacemen claimed that the gas should be taken off either from the center of the furnace or at several points symmetrically arranged around the furnace top. Others claimed that the gas, having gone through the stock column, had done its work and that the location of the outlet was a matter of no importance, and that one large outlet located on one side was cheaper and simpler than any other arrangement and just as good.

In connection with furnace tops, I shall show a design of top arranged to take the gas out at the center, which worked successfully for many years and gave but little trouble. It was, however, impossible to make the top quite so simple in this way as with the outlet on one side, and so the great majority of furnaces built in the United States up to 20 years ago were constructed on the latter plan, although in discussing operation I shall show what is to my mind an indisputable proof that a single side outlet produces an unsymmetrical passage of the gas through the furnace and cannot lead to the best work.

As furnaces and their outputs grew they produced a vastly larger quantity of gas, so their designers provided more gas outlets, two and even up to five or six. Good practice now very generally uses four, though in my judgment three properly located are sufficient.

DOWN-COMERS.

This introduction of multiple outlets introduced other difficulties into the design of the plant.

With a simple outlet the down-comer could drop almost vertically to the ground close to the base of the furnace, but with this growth of output, necessitating multiple outlets, came the vast increase of dust which I have mentioned and the necessity for providing some means for its removal. As long as the gas traveled on a steep downward slope, the dust would accompany it, but when the dust reached the horizontal passages leading to the stoves and boilers and from these to the stack, it settled in them and obstructed them so rapidly as to constitute a serious obstacle to continuous and satisfactory operation.

Means therefore had to be provided for the removal of the dust at the foot of the down-comer and for this purpose chambers, at first only a little larger than the gas mains were introduced, but as conditions grew worse and worse these were increased in size and required, therefore, to be placed further from the furnace in order to give the necessary room for operation.

This threw the foot of the down-comer away from the furnace at its base, while the necessity of reaching more than one outlet threw its top back, from the closest point on the top of the furnace shell, to the center line of the shell when the two outlets were used, and finally to the back or opposite side when four or more were used. These two factors flattened the slope of the down-comer from almost vertical to a slope well below 45 degrees.

In some of the earlier installations these conditions were made still worse because it was considered necessary to have the down-comer enter the top of the dust-catcher in the center of the latter and this reduced the vertical height, at the same time all the other factors above mentioned increased its horizontal reach. I think that the slope of the dust-catcher on some of the plants built about the time of the Duquesne revolution was not more than 30 degrees. These were extremely unsatisfactory in operation because not only would dust lodge in them but also coke and other materials from the charge; they did not free themselves under any circumstances and no matter how large they might be built, they filled up until the velocity of the gas through them was great enough to scour a passage-way through the accumulation on the bottom slope, this, of course, involving high top pressure and consequent leakage on every joint not tightly sealed.

EXPLOSION DOORS.

Down-comers are generally provided with explosion doors for two purposes: First, when furnaces are stopped it is almost impossible to prevent air being drawn into the gas main at some point or other. This air mixes with the gas and produces an explosive mixture. When operation is resumed this mixture is ignited at the boiler or stove burners and an explosion follows which in some cases is violent enough to burst the main, dust-catcher and down-comer unless it is relieved by suitable safety-valves or explosion doors.

Second, the furnace itself is liable to slips or explosions in which a pressure of several pounds to the square inch, ordinarily only occurring at the lower levels of the furnace, reaches the top and would do it great damage unless properly relieved.

This latter theory has been combatted by Mr. Julian Kennedy, who has claimed that explosions were more violent in proportion as they received freer vent; comparing the conditions which arise at such times to those occurring when the cork is removed from a bottle of charged water, if this be done suddenly a great proportion of the contents of the bottle is violently ejected, but if the cork is held back and the gas pressure allowed to pass off slowly, none of the contents of the bottle are thrown out. In accordance with this theory the tendency in recent years has been to provide many less explosion-doors than were formerly thought to be necessary, and the results have very largely confirmed the theory, though many furnacemen are not willing to go as far as advocated by Mr. Kennedy and do away with explosion doors entirely.

One design, made about the time of the Duquesne revolution, was intended to be the best possible regardless of expense. Some five or six outlets were provided around the top of the furnace, and these were all connected with an annular main, from one or two points on which the branches of the down-comer led off. Explosion doors were arranged on the outside of this annular main, which, of course, was a few feet below the operating platform of the furnace top and in order to provide access to it a supplementary platform was built a few feet below.

This system has almost all of the disadvantages which could be worked into one design. On the side opposite to the down-comer there was so little current of gas that the annular main became sufficiently choked up to make it virtually useless and one or two outlets on the side next to the down-comer carried off all the gas, practically as though the annular main did not exist. On account of the large size and distant location of the dust-catcher and the wide stretch of its branches to reach the opposite sides of the annular gas main the slope of the down-comer was exceedingly flat, and it is probable that after it was in operation a short time more than half its area was choked up and not in active use. One of the worst features of the design was the location of the explosion doors which, it will be seen, came just under the main operating platform. Owing to the choked condition of the down-comer, the top pressure was high and the explosion doors were generally leaking more or less; if the gas caught fire it burnt underneath the top platform so as to damage the steel work, and if it escaped unburnt the gas came up onto the top platform in sufficient quantity to make

it dangerous to stay there any considerable length of time.

It may not be amiss to say a word here as to the general design of explosion doors. These are always made hinged, but are located in two different ways; first, so that the plane of the door is horizontal when closed; second, so that it is steeply inclined or vertical when closed. The latter design is radically wrong and should never be used because the moment of the door due to its weight, is little or nothing when it hangs vertical, consequently a slight pressure is sufficient to force it from its seat, but as its moment rapidly increases a much greater pressure is required to force it to open wide as it should when it is needed at all.

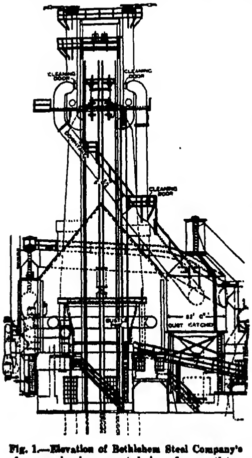


Fig. 1.—Elevation of Bethlehem Steel Company's furnace, showing correct design of gas outlets.

The horizontal door works exactly the opposite way, exerting its maximum moment when it is closed so that it is very easy to keep tight under ordinary conditions. But when a considerable increase of pressure occurs, forcing the door open to relieve it, the moment of the door decreases as it opens, so that it operates more and more easily as it opens wider. This seems at first sight to be an insignificant detail, but as a matter of fact, I have seen great annoyances caused by vertical doors, so little gas leaking from them can be objectionable either by burning and damaging the structure or by polluting the air, that the final result is to have a rigid clamp put on the door which virtually destroys its usefulness for its primary purpose even though it may not completely eliminate the leakage.

Fig. 1 shows a design of gas outlets and down-comer which secures practically all the important advantages. The drawing shows the "E" furnace of the Bethlehem Steel Company. The outlets are four in number rising from the conical top of the furnace shell. The down-comer instead of connecting directly with the outlet openings on the furnace shell on the back or high side, connects with the outlet pipes at a point several feet above the operating platform and thereby secures sufficient height to give it a slope steep enough to free itself. The explosion doors are placed on the top of these high outlet pipes many feet above the operating platform and if they leak no harm is done. If the gas burns it cannot strike anything to destroy, and if it remains unburnt it pollutes the air far above the heads of those who may have occasion to be upon the operating platform.

In the early days the down-comers were made of quite thin pipe entirely unlined, and these gave remarkably good service considering the relatively high temperature of the gas they sometimes had to handle, temperatures of 800 or even 1,000 deg. Fahr., in regular operation, being not uncommon, while, of course, very much higher ones occurred during slips.

In modern practice, however, the down-comer is always built of very substantial steel plate and lined with circle bricks from 3 to 4½ inches thick. This makes an almost indestructible construction but a very heavy one, so that due care must be taken to support the weight of the down-comer at both ends.

DUST-CATCHERS.

Dust-catchers were not considered a necessary part of a plant until within the last 20 or 25 years. The first ones were crudely designed, simply with the idea of providing an enlargement in the gas main in which the velocity of the gas would be reduced and its dust contents dropped to the bottom by this reduction in velocity. Ordinarily very inadequate means were provided to prevent the gas current from picking up again the dust it had once deposited, and the efficiency of the apparatus was in some cases so low that the quantity of dust recovered was inappreciable, and after several years trial the dust-catcher was thrown out and replaced by a plain section of pipe. Eventually the idea took shape of combining centrifugal force with the reduction in velocity to throw out the dust.

The sketch, Fig. 2, illustrates diagrammatically the construction which came to be standard for the first type. Fig. 3 shows an early type sometimes used to secure the centrifugal effect. The tangential inlet into the dust-catcher body constitutes the principal difference in the two types.

The difficulty of preventing the dust from being picked up by the gas current after being deposited, was a serious one, and its solution was sought by several furnacemen and several designs were brought out to overcome it by having the dust impinge upon the surface of water to which it would adhere and from which the gas could not pick it up again.

One of the earliest designs to embody this principle was that of Mr. F. E. Bachman, then manager of the Northern Iron Company, at Port Henry, N. Y. Mr. Bachman built a dust-catcher in general appearance not differing greatly from the ordinary type provided with a tangential inlet as shown in Fig. 3. The shell of this instead of being lined with firebrick, as in ordinary constructions, was sprayed inside with a great number of small jets of water which produced a water film running down over this whole interior surface. Centrifugal force threw the gas against this surface to which the dust adhered, and was carried to the bottom by the flow of the water film. The gas only being exposed to the surface of the water for a short time did not absorb enough water vapor to affect its thermal value materially. This dust-catcher was in operation for a number of years (as far as known to me it still is) and gave excellent results. The stoves remained clean and serviceable, although the furnace was charged exclusively with magnetic concentrates, which were quite fine.

Another design to secure this result was that of Mr. R. C. Steese, whose dust-catcher is shown by Fig. 4. The body of the dust-catcher is horizontal and filled with water to about one-third of its height. The gas enters at one end so as to impinge on the surface of the water and is reflected therefrom into a semi-circular passage which brings it back to impinge upon the water a second time. A second semi-circular passage repeats the operation once more and the gas is finally discharged at the far end of the dust-catcher.

This design avoids the maintenance of the sprays required by the Bachman apparatus, but, on the other hand, the surface of the water is not constantly and rapidly renewed as it is in the Bachman design, and this is a point of much importance because when the surface of the water becomes fouled by a heavy layer of dust, other dust impinging upon this is not held but liable to be picked up again and carried on by the gas.

Another dust-catcher which uses the principle of having the gas impinge upon the surface of water is the invention of Mr. B. F. Mullen, of Leetonia, Ohio. This dust-catcher has had the widest appliance of any apparatus of its type. The design is shown in Fig. 4a. The external shape of the apparatus is not unlike that of the standard dust-catcher. The gas enters at the top and passes into the central chamber shown. This chamber is suspended from the dome of the dust-catcher, its shell is lined with firebrick and its bottom constitutes a tube plate supported by the suspension rods *L*. Through the tube plate project a great number of short tubes through which the gas is forced to pass at a considerable velocity. The bottom cone of the apparatus is filled with water to a level from 4 inches to 6 inches below the bottom of the tubes. This level is maintained by overflow through the ports *H* around the circumference of the dust-catcher body.

Fresh water is introduced into the center through the pipe shown, and flows regularly outward to the outlet ports *H* through which it discharges. This keeps the surface of the water constantly in motion and prevents its becoming too foul to hold the dirt thrown upon it.

After the gas leaves the tubes and impinges upon the water surface it passes into the annular space around the central chamber and so to the outlet at the side. The top of the outlet trough just beneath the ports *H* is sealed by a conical plate, the bottom of which is riveted to the bottom of the trough, while its top is riveted to the shell of the dust-catcher proper.

The light dust which lodges on the surface of the water is carried away by the flow of the water, while the heavy dust which penetrates the surface is flushed off from time to time through the bell valve at the bottom of the cone. A later design is modified so that the outlet trough for the waste water is inside the main dust-catcher structure instead of outside of it, but the principle remains the same.

This dust-catcher has given very good satisfaction in use. The principal point to be guarded against is any fluctuation of the water level which will permit the end of the discharge nozzle to become wet, because, if they do so the dust will rapidly build upon them and in time

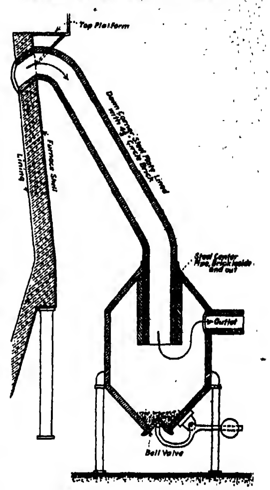


Fig. 2.—Early form of typical dust catcher.

they will become completely obstructed. A fact not generally recognized is that flue dust has a very cement-like quality and that when dampened it sets almost as hard as a good cement. This fact has proven the destruction of the number of wet dust-catchers whose designers did not know how to provide against this difficulty.

Through the courtesy of the representative of the Mullen washer, I have obtained a copy of the results of a test made on one of these washers by the superintendent of one of the largest blast furnace plants in the country, with a view to finding out if the apparatus were suitable for the conditions at this plant. The results of this test showed that the gas leaving the dust-catcher contained 2.28 grains per cubic foot of dust and after leaving the gas washer it contained 0.75. The representative of the gas washer claims that it is capable of doing considerably better work than this, but even this reduces to a third the total amount of dust carried into the stoves and boilers, as there is a very considerable proportion of the total dust carried through by the stack gases without being deposited; this reduces the proportion which lodges in the stoves and boilers, to their detriment, by a considerably greater percentage, and at the original plant where this washer was installed at Leetonia, Ohio, experience proved that they could run the stoves for the whole blast without taking them off the furnace for cleaning, which would be quite impossible without some means for reducing the dust in the gas far below the percentage which it contains on leaving the dust-catcher.

Many other types of dust-catchers have been built and tried out, but those described give the broad outlines of the art as it existed before the introduction of the gas engine. This forced a further step and a very long one in the direction of cleaning the gas, and as has so often happened, knowledge of the subject gained in learning to clean gas for gas engines has proved of great advantage in directions not contemplated when the work was undertaken. There seem to be definite limits to the degree to which the gas could be cleaned by any type of [illegible] [illegible] centrifugal force, or [illegible] [illegible] combination of any of these. [illegible]

as obtainable is barely sufficient for moderately good practice with the stoves, and as I have previously explained, great economies were effected by cleaning the gas a step beyond this point for use with stoves.

Most of the processes used for the next step in cleaning have involved scrubbing the gas with water and this introduced another element in the situation. The gas as scrubbed picks up water vapor enough to saturate itself at the temperature at which it leaves the scrubber and this has a somewhat complicated effect. The gas as it comes from the furnace at a temperature of 300 degrees to 500 degrees, carries a very considerable quantity

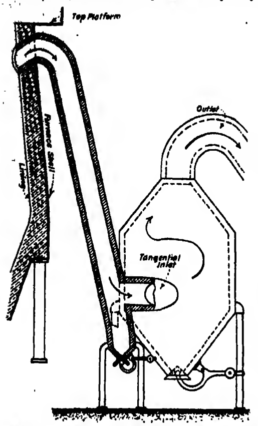


Fig. 3.—Typical form of centrifugal dust catcher.

of water vapor picked up from the stock, which, in a large proportion of modern practice, is heavily sprayed with water just before being charged into the furnace. This water vapor is somewhat of a detriment to the gas since it acts as ballast during combustion and prevents attainment of as high a temperature as would be reached with the same gas at the same temperature, dry. By scrubbing the gas with water this temperature is reduced and its saturation point is so much lowered that water may actually be removed from it instead of being imparted by the scrubbing operation.

It is obvious that we have here two conflicting effects. The reduction of the temperature of the gas itself is bad because the sensible heat is an appreciable percentage of the total, and if this is removed by any means before gas reaches the burners such removal represents an absolute loss. On the other hand, hot gas can carry an enormous amount of water vapor and this moisture going through the system acts as a damper on the combustion and prevents the temperature from rising as high as it otherwise would. Therefore, to remove the moisture is in itself a benefit.

There has been a certain amount of misapprehension on this subject. There have been in recent months, two papers on the subject of gas cleaning, of which jointly the value probably exceeds anything published in England previous to that time. These are the papers of Mr. W. A. Forbes, "The Cleaning of the Blast Furnace Gas," before the October, 1913, meeting of the American Institute of Mining Engineers, and that of Mr. A. N. Diehl at the February, 1914, meeting of the same institute, entitled "Data Pertaining to the Gas Cleaning at the Duquesne Blast Furnaces."

From the former of these I shall presently quote extensively and from the latter also to a considerable extent, but both of these, in my judgment, give an erroneous idea as to the relative importance of removing moisture and of cooling gas. Table 2 of Mr. Diehl's paper is reproduced here as Table 1.

It will be seen that he gives calculations showing the amount of heat obtainable per cubic foot of gas under three conditions.

First—Washed and cooled to 70 deg. Fahr. and saturated at that temperature with water vapor.

Second—Washed and cooled 125 deg. Fahr. and saturated at that temperature.

Third—Unwashed at 400 deg. Fahr. and containing 35 grains of moisture per cubic foot; in other words, its natural condition as it comes from the furnace.

Three temperatures for the escaping products of combustion from the stack, 400 deg. Fahr., 500 deg. Fahr. and 600 deg. Fahr., are taken for each of the three cases.

Turning now to the third line from the bottom, "Total heat obtained per pound of dry gas consumed," it will be seen that the amounts in the three cases, all at 500 degrees stack temperature, are 1,076.6 British thermal units for the first, 1,068.43 for the second and 1,166.49 for the third. It is obvious that the most available heat is to be obtained with hot gas in spite of high content of moisture.

Mr. Diehl gives a percentage figure for the three cases in the second line from the bottom of 83.23 per cent, 78.4 per cent and 80.31 per cent. Based on these percentages he states that the dry cold gas gives the highest percentage of available heat.

This is obviously incorrect, as the highest percentage must plainly coincide with the largest absolute amount of heat obtained on any correct basis of figuring. The error has arisen by counting as available the latent heat of vaporization of the water vapor in the gas in all cases. But this is in fact not available under any known conditions of boiler or stove operation since it would require gases to be cooled far below 212 degrees to precipitate much of this moisture and recover its latent heat.

It is obvious that if the burnt gas comes in at 400 degrees and goes out of the stack at 400 degrees no loss whatever has occurred, while if it goes out at 500 degrees or 600 degrees, the only loss is that in superheating this small quantity of steam 35 grains, or 0.005 pounds of water vapor, with a specific heat of 0.48 through a range of 100 degrees or 200 degrees, making a loss per cubic foot of gas of only a fraction of one thermal unit.

In regard to the effect on the combustion temperature, the results are similar. The quantity of air required for combustion is about equal in weight to the gas itself, therefore the reduction of the initial temperature of the gas by a given amount results in a reduction of the temperature combustion by about one-half of that amount; to cool the gas from 400 deg. Fahr. down to 70 therefore reduces the theoretical combustion temperature by about 160 degrees. The removal of the moisture tends to raise the theoretical combustion temperature but quantitatively the amount of increase is smaller than the decrease due to the loss of sensible heat of the gas, about 100 degrees against 160 degrees.

When the gas comes from a furnace which does not work a wet burden of ore or wet fuel, the conditions become very much worse for wet scrubbing, because in that case there is but little moisture in the gas to be removed by a reduction of the temperature and therefore such reduction represents a net loss both of combustion temperature and of thermal efficiency due to lower combustion temperature.

In the discussion of the paper of Mr. Forbes above mentioned, it was stated by Mr. S. K. Varnes, of the

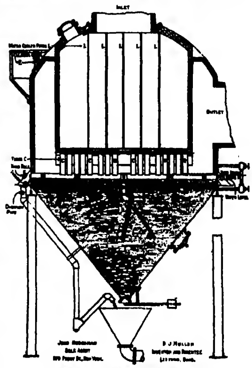


Fig. 4a.—Mullen gas washer.

Pennsylvania Steel Company, that at their furnaces they had introduced gas washers for the stoves but that they had been forced to abandon them because of the increased moisture and decreased temperature of the gas which resulted in a decided lowering of the combustion temperature and corresponding reduction of the blast temperature that could be obtained from the stoves. On the other hand, great benefit has been derived from wet scrubbing, where wet ore is used. Thus it will be seen that each case must be handled on its merits. Clean gas is always desirable, and undoubtedly much cleaner gas will be used in stoves and boilers than we have been accustomed to in the past, but wet scrubbing should only be adopted after the most careful analysis of the conditions to see whether the net results will be beneficial or not, and if so, to what extent. There is but little use in supplying stoves with clean gas and then finding that we can get from them only lower blast temperatures than we could with dirty gas.

(*To be concluded.*)

TABLE 1.—HEAT AVAILABLE PER POUND OF DRY BLAST-FURNACE GAS UNDER VARIOUS CONDITIONS OF INITIAL TEMPERATURES AND MOISTURE CONTENT. COMBUSTION AIR CONSTANT CONDITION.

	Washed Blast-Furnace Gas at 70° F. with Moisture Saturated at 70° F. Combustion Air at 70° F. with Moisture Saturated at 57° F.			Washed Blast-Furnace Gas at 125° F. with Moisture Saturated at 125° F. Combustion Air at 70° F. with Moisture Saturated at 57° F.			Unwashed Blast-Furnace Gas at 400° F. with 35 Grains Moisture per Cu. Ft. Gas at 62° F. and 30 in. Hg. Combustion Air at 70° F. Moisture Saturated 57° F.		
	400° F.	500° F.	600° F.	400° F.	500° F.	600° F.	400° F.	500° F.	600° F.
Total Heat Expended Above 32° F.									
Fuel Gas.									
Sensible heat in dry fuel gas, B.t.u.	0.322	0.322	0.322	22.442	22.442	22.442	90.61	90.61	90.61
Sensible and latent heat in moisture, B.t.u.	16.688	16.688	16.688	94.420	94.420	94.420	61.37	61.37	61.37
Latent heat of combustion, 1 lb. dry fuel gas, B.t.u.	1,253.000	1,253.000	1,253.000	1,253.000	1,253.000	1,253.000	1,253.000	1,253.000	1,253.000
Total, B.t.u.	1,270.010	1,270.010	1,270.010	1,369.862	1,369.862	1,369.862	1,404.98	1,404.98	1,404.98
Combustion Air.									
Sensible heat in dry air, B.t.u.	6.302	6.302	6.302	6.302	6.302	6.302	6.302	6.302	6.302
Sensible and latent heat in moisture, B.t.u.	7.729	7.729	7.729	7.729	7.729	7.729	7.729	7.729	7.729
Total, B.t.u.	14.031	14.031	14.031	14.031	14.031	14.031	14.031	14.031	14.031
Total heat expended, B.t.u.	1,284.040	1,284.040	1,284.040	1,384.00	1,384.00	1,384.00	1,418.70	1,418.70	1,418.70
Total Heat in Products of Combustion Above 32° F.									
Sensible heat in dry products of combustion, B.t.u.	144.65	182.14	222.69	144.65	183.14	221.60	144.65	183.14	224.63
Sensible and latent heat in moisture, B.t.u.	31.41	35.39	42.37	117.34	126.12	135.54	94.16	99.07	104.06
Total heat in products of combustion, B.t.u.	176.06	217.06	265.06	261.99	309.26	357.01	238.81	282.21	328.77
Heat Balance.									
Total heat expended, B.t.u.	1,284.040	1,284.040	1,284.040	1,384.00	1,384.00	1,384.00	1,418.70	1,418.70	1,418.70
Heat lost in products of combustion, B.t.u.	176.06	217.06	265.06	261.99	309.26	357.01	238.81	282.81	328.77
Total heat obtained per lb. dry fuel gas consumed, B.t.u.	1,107.97	1,076.60	1,028.57	1,122.00	1,068.43	1,026.78	1,180.89	1,166.49	1,115.93
Per cent heat obtained per lb. dry fuel gas	86.26	83.23	79.31	81.29	78.04	74.20	83.23	80.31	77.08
Per cent heat lost in products of combustion	13.64	16.77	20.49	18.78	22.26	25.67	16.40	19.90	22.90

Profits from Public Forests

THAT the public forests might be a valuable property for the community is pointed out by the Forest Service of the Department of Agriculture, which cites the case of the town forests of Baden-Baden, Germany, where scientific forestry is practiced. These forests yield a profit of \$5.25 per acre, or a net revenue of \$67,500 annually.

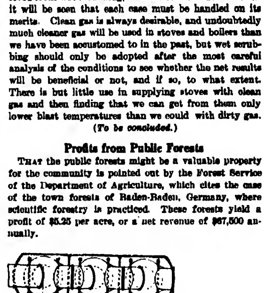


Fig. 4.—Steese and Ford gas washer.

Hypnosis or Agony of Fear?

One of the subjects often discussed in the press, yet never settled, is the question whether a snake can hypnotize a frog or bird so completely that it becomes helpless and allows the snake to seize and swallow it. The unlucky little creatures, it is asserted, generally become rigid and unable to move at the sight of the enemy, but in some cases they advance toward the snake as if drawn by some mysterious power and even spring right into its jaws. Once by way of determining whether a snake's eye really possesses this occult power the experiment was tried of pushing cautiously a board between the reptile and the frog hopping toward it. In a moment the spell was broken, the frog fled in joyous springs and the snake vanished into its hole. This seemed to be conclusive proof that the hypnotic state had been produced.

A somewhat different view of the matter is brought forward in the scientific notes of the German journal *Prometheus* by Herr Pfister of Rappoltsweiler. He is somewhat doubtful of the theory given above and asks how it is that such occurrences have never been observed among snakes in confinement. Or how it happens that rabbits and rats in a cage of snakes seem so unconstrained, nibble placidly and run around as though they had no suspicion of their impending fate? Rats have been known when driven by hunger to gnaw at the snake and even to eat it up altogether.

Our author's reasoning in maintaining his views is about as follows: It is certain that a human being can exert a strong influence upon another or can hypnotize him. As a rule this is nothing more than the power that a strong mind exercises over a weaker one, a forceful character over an undeveloped one. This can be observed any day in the case of a teacher in the school, of parents with their children, of a judge in the exercise of his office. A sharp look is often sufficient to break down the defiance of the wrongdoer. Among human beings this exercise of influence holds good, but how can the expressionless eye of a snake exert such a power over a frog, an animal so low in the scale of creation? An animal tamer can perhaps hold a lion or tiger within bounds by the power of his eye or rather by his daring demeanor. But let him try to exert this power over a frog!

The supposedly hypnotic cases, continues Herr Pfister, should more probably be attributed to the fact that animals are rigid with fright when they perceive an enemy, just as men are when facing great danger. Moreover the frog, like many other animals, has the habit of simulating death in case of necessity until the danger is past. As snakes only attack living animals, in this way the frog is frequently able to save itself. If a frog should really hop toward a snake the probable explanation of this is that it does not suspect that the reptile lying motionless could be dangerous to it.

Our author explains the behavior of little birds at the sight of a snake in the same manner. No occult power drives a bird toward the enemy, but its anxiety for its young. Whether the enemy be a snake, a cat, a marten or any other predatory animal, mother love leads the bird to forget its own danger entirely. Screaming with alarm it flits back and forth, strikes boldly at the enemy, seeking in every way to drive the intruder off, and often falls a sacrifice to its daring. There is no question of hypnosis in such a case.

Herr Pfister thinks we should be very cautious in accepting stories as to what people have observed, as imagination, the unusualness of the phenomenon, surprise and alarm often confuse the perceptions. Prof. Doflein in his work "The Animal as a Part of Universal Nature" says: "It has often been observed that birds upon the approach of a snake remain motionless as if under a spell. This was held to be a kind of hypnotic influence, which it was asserted arose from the glistening of the snake's eye, from the sheen of its skin and from the uniform swaying back and forth of its head. According to others it was the sight of the snake which made birds stiff with fright. Investigations made at the Zoological Garden in London, however, led to an entirely different result. No species of animal, with exception of the ape, looks upon the snake as something to be feared and exhibits signs of terror at the sight of it. Many animals show rather something like curiosity and look at a striking object with great attention, but without moving, whether the object be a snake, a ribbon or a human finger. If therefore the snake throws itself quickly at the right moment on its prey the victim is caught, and this without any magic."

The same opinion is also reached by Dr. Kurt Floericke in his work "Reptilia and Batrachia of Germany." He says: "The spell of fascination exercised by the snake's eye, whereby the victim is said to be held in a measure to one spot in order thus to fall a more easy prey, should at the present day be regarded as an exploded theory."

Our author quotes further Brehm's "Animal Life," which simply gives all the cases which the writer has been able to draw from reliable sources without expressing a positive opinion one way or the other, while Prof. Doflein calls any such story "an interesting scientific fable without actual basis."

The Lightest Known Wood

When one sees and handles for the first time a piece of the wood of the ambach or ambatscha tree he immediately conceives the idea that the material would serve as an admirable substitute for cork. Upon inquiry he soon learns that all woods which are characterized by a very low specific gravity and softness have been used only to a very limited extent in place of cork because all of the so-called cork woods known to man do not possess the high elasticity, impermeability and durability peculiar to cork. With the single exception of cork wood or balsa (*Ochroma lagopus*) of tropical America, which is used for making life preservers, these soft, light and pith-like woods rarely enter the markets. Their uses are for the most part confined to carving and ornamental work in the countries where the plants are native. The adaptation of shola or sola (*Aeschynomene aspera*), a remarkably soft light wood used in the manufacture of shola hats, is perhaps one of the principal exceptions to the rule. The shola tree is found growing in India and Ceylon, where it is used extensively for making hats out of the spongy substance developed on the stems when growing in the water as they generally do. These hats are of remarkable lightness and are well adapted to the climate as they are poor conductors of heat. The wood is employed also in many parts of India and occasionally in England, and to a lesser extent in the United States, for fishing floats, models and for an infinite variety of ornamental purposes. Latterly, however, shola and other similar soft woods have been applied for the packing of machinery bearings.

Ambach, upon which experiments have been made for this and other purposes, is a leguminous plant known to botanists as *Herminiera elaphoxylon*, a native to the Nile and Lake Chad regions. It is called ambach or ambatscha in the region where it grows, and the wood has attracted considerable attention under the names of ambach and tripol, the latter name is probably derived from the name of the town or region from which the wood is principally shipped. The English speaking people along the Nile call it pith tree because the wood resembles the pith of elder or of other trees having a very light pithy center. The tree grows to a good size, forming tolerably thick trunks, and is of very rapid growth. It is said to attain a diameter of 6 inches in two to three years, when it dies and another young tree springs up from the same underground parts. The growth of these plants is so rapid and occurs in such great abundance that it frequently chokes up the channels of the numerous tributaries of the upper Nile. The wood is remarkable for its very soft texture and its appearance of a mass of pith. It is exceedingly light in weight, brittle and is nearly white when it is cut, but turns slightly darker upon exposure to light and air.

Ambach is the lightest wood in existence. A sample of balsa from Trinidad exhibited at Philadelphia in 1876 had a specific gravity of 0.120, or about seven and one half pounds per cubic foot. The specific gravity of common cork (the bark of *Quercus suber*) is given by Ganot as 0.240. There are no figures extant on the specific gravity of ambach, but on an average it is much lighter than either balsa wood or cork. Owing to its extreme lightness the natives use it to assist them in swimming across the rivers. It has also been used by the natives in Africa for making hats and floats, and has occasionally been shipped to England and the United States for making floats for fishing tackle and as a substitute for cork. It has been found to split too easily under radial tangential pressure, and it is soon water soaked and cannot be used successfully for the purposes for which ordinary cork is now employed.

Although ambach is very soft it has been found that it cannot be used for such purposes as packing machinery bearings and delicate instruments, because it tends to wear away the metal where it rests on the wood, which contains numerous minute crystals of calcium oxalate. These crystals have also a great deal to do with the dulling of tools used in cutting the wood. These qualities are recommendations for the use of this wood as razor strops, for which it has been employed successfully for a good many years. The woody tissue of the flowering stems of the American aloe (*Agave americana*) is often cut and shaped by the people in the country where the aloe grows into the form of strops, and there is no doubt of its efficiency for this purpose. The wood of ambach is more compact, even grained, and apparently more durable and serviceable than the aloe.

Locating Metals in Wounds

It is often difficult to locate bits of metal in wounds, such as rifle bullets, fragments of shells or shrapnel, and the suggestion has been made that the Hughes induction balance can be of great use for the purpose. The balance consists of a battery and interrupter, in series with two primary coils, on which are wound secondary coils connected in series with a telephone, the leads are crossed, and the coils are exactly alike, so that normally their effects are exactly neutralized, and no sound is heard in the telephone. When, however, a metallic body is placed near one of the coils, the eddy currents induced in the metal react upon the coil and disturb the balance, so that a sound is heard in the telephone. When the metal is magnetic, as in the case of splinters of shell or bullets, the effect is much increased. Thus the device can be used to indicate the presence and to some extent the nature, of a metallic body, and its approximate position.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, FEBRUARY 6, 1915

Published weekly by Munn & Company, Incorporated. Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer; all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year	$5.00
Scientific American (established 1845)	3.00
American Homes and Gardens "	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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VOLUME LXXIX] NUMBER [illegible]] NEW YORK, FEBRUARY 13, 1915 [10 CENTS A COPY $5.00 A YEAR]

A Votive axe in pottery

A panoramic view of the excavated area in the north of the Royal City

Bronze scepter head.

Shrine of the Royal City a short distance outside the walls to the south showing the two stelae, or tablets bearing inscriptions, which are believed to be the best continuous Ethiopian inscriptions yet discovered.

A wooden model illustrating the plan of the sun temple with the fore part as a sun-dial

A cameo of onyx with galloping horses to represent day and night—Greek of B C 250

Observatory showing two observation stones and wall of graffiti and steps to tank. The baths in the tank are shown in another illustration Meroë will soon be covered by the waters from the Assouan dam.

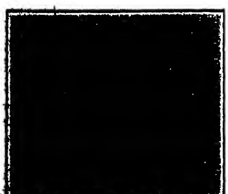
Fittings from the royal throne—B. C 500

A bath in observatory building (Plan showing locations of baths.)

An altar with a fetish

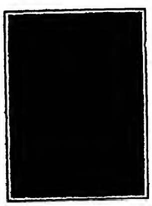
A stone recording observed angles.

A bath recently discovered in the street leading into the palm court

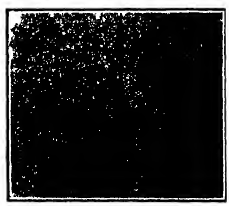


A [illegible] on the wall of the observatory [illegible]. An astronomer [illegible] instrument.

Great Stela inscribed with 42 lines of Meroitic writing that has not been deciphered.



A graffitio giving astronomical calculations and a record of observations.



Records and calculations on the walls of the observatory

A diagram of the stone for recording observed angles.

An ancient center of astronomical science.

MEROË, THE ROYAL CITY OF ETHIOPIA.—[See page 98.]

Meroë the Royal City of Ethiopia

Important Discoveries that Indicate Advanced Knowledge of Arts and Sciences

LOCATED on the River Nile in southern Nubia the region of Ethiopia of olden times was the city of Meroë which has long been the scene of much archaeological investigations as it has yielded many antiquities that have thrown much light on the history of forgotten races and nations and their foreign relations and influences (at first Egyptian then Hellenistic-Greek and subsequently Roman with reason to believe that evidences of still other races will be discovered) which dominated their development During the past season valuable discoveries were made which were described in the *London Illustrated News* by Prof John Garstang of the Institute of Archaeology at the University of Liverpool and many of the objects recovered that were exhibited in London were illustrated in the above publication from which our illustrations and information are derived

These objects illustrate the character of Ethiopian culture from the establishment of the court at Meroë in the sixth century B C to the destruction of the city in the third century A D but one of the most important results of the explorations has been the proof that the city of Meroë was a center of astronomical science of no small importance The description by Prof Garstang of the discoveries is as follows

The season 1914 has advanced our work in the royal city at Meroë to a penultimate phase We have now been able to connect up the various areas in which we have been excavating for some years and to uncover completely the northwestern corner so that the whole of the northern portion of the city has now been brought to view It only remains to uncover and enclose the southern portion to bring the excavation of this central feature of the site to completion The Sudan Government has already instituted a convenient service of trains and accommodation for visiting this ancient capital of the country

The buildings of the later portions of the Middle Meroitic period (circa B C 150) reveal the city at its prime The main entrance through the northern wall led on through an avenue of trees towards the center of the city where on the left hand or eastern side there seems to have stood a public building fronting or replacing the now time-honored portico which had stood there it would seem in the sixth or seventh century B C Almost opposite was an indefined building of solid foundation which to judge from the records of observation and calculation found along its western side may indeed at that time have been an observatory and residence of an astronomer The palace of these times lay immediately to the left of the main gateway a large building with central courtyard and veranda Opposite the palace in this quarter is the enclosure which seems to have been walled off as a place for interring the cremated dead The crematorium itself has been found in the building at the head of the street last mentioned the flues and hearth still remain, and the floor was found littered deep with partly incinerated bones

While the development of the general plan has not been without its measure of surprises, it has nevertheless much amplified and amplified our provisional chronology The fact that the early gateway and the secondary gateway through the northern wall were obviously in contemporary use being linked together by the palace of Netog Amon and the road-system around this building, led us *inter alia* to the inevitable conclusion that the main city wall was built at the beginning of our Hellenistic Period in the early third century B C Some buildings thus pre-existed the main city wall which was only raised around the area some centuries after these had been built

There is evidence to show not only that there was a place and equipment for astronomical observations at Meroë in the second century B C but also that it was in close proximity to this building for on what was then the outside western wall we found a number of graffiti representing both calculations or record of observations and actual sketches of two instruments which would seem so far as they can be understood to correspond to a transit instrument with circle and an azimuth instrument

A special flight of steps subsequently disused seems to have led down from that side of the building to the outer level where these graffiti and other features are to be found The other material evidence consists in the remains of two columns or pedestals One of these columns is hexagonal the other square The latter is carefully set upon a stone plinth in such fashion that certain markings on its side correspond exactly to marks upon the base and the alignment is controlled It would seem from a sighting point upon the further side of the hexagonal column This alignment is still true and its bearing east of magnetic north is 128½ degrees The magnetic deviation lies probably between 2½ degrees and 3 degrees west at the present time

Upon the face of the square column which is turned towards the other that is its western face, there are engraved three lines which if produced upwards would meet more or less accurately in a point The outer lines converge upon the middle line so as to make angles in each case of approximately 14 degrees The middle line is not (at the present time at any rate) truly vertical but is inclined at an angle of approximately 3¼ degrees the bottom of the line being to the south of the point vertically below the point of intersection of the three lines in question This face of the stone is not set in the meridian nor is it quite true in its own plane Its bearing along the bottom is 37¼ degrees east and along the top 40½ degrees There is a possibility of error in our record of these details amounting to about ± ½ degrees

We have thought it best to publish these bare facts because astronomers everywhere cannot fail to be interested in the obvious significance not only of this diagram but of the calculations and the designs upon the wall

The latitude and longitude of Meroë, determined 5 years ago are 16 degrees 56 feet 18 inches North, 33 degrees 44 feet 18 inches East, and it will be noticed at once that the inclination of the southernmost of the three lines to the vertical upon the square column almost corresponds with the latitude.

There are many interesting records in the pages of Pliny, and some in other writers, all tending to show that the astronomers of the second and third centuries B. C. made consistent observations at various points in and about the Nile basin with a view to determining latitude and other astronomical data. It is related, suggestively, that at Ptolemais, which was on the Red Sea coast, very nearly in the latitude of Meroë, an interval of 45 days elapsed between the summer solstice and the two days (before and after) whereon the shadows of the sun were vertical at noon (Pliny's 'Natural History,' II., 75—VI., 34) Now the graffiti of the wall include the calculation or record of a series of observations which will be seen to involve the number of forty-five on each side of an equation with a difference at the foot on one side of three, and on the other side of ten. This summation of figures is represented in units arranged in five groups of three and in three lines in each case, and it is obviously suggested that it is really the record of observations kept daily and that 45 days on each side was the basis of calculation Pliny tells us, significantly, that at Ptolemais which is approximately on the same latitude as Meroë, the shadow of the sun was vertical *45 days before and after* the summer solstice.

There is another significant feature about the position of these astronomical monuments, for we are told that when at the end of the third century B C Eratosthenes determined the latitude of Assuan and the size of the earth, he made use of a deep well for the purpose of his observations The date of our monuments is, however, more nearly that of Hipparchus, who is credited with many improvements and additions to astronomical instruments

Outside the city we made further experimental examination of three spots, including a number of prominent mounds located along the south side of the Temple of Amon

One other site was examined, an isolated mound lying some 2 or 3 kilometers to the south, not far from the village of Hamadab The most immediate result was the discovery of two great stelae, inscribed in Meroitic cursive characters both apparently historical narratives. A few hours work showed the important nature of the inscriptions

The two stelae are of the characteristic dark grit used anciently in this locality for special purposes, such as altars steps, thresholds, and the like They were found left and right of the entrance to the shrine mentioned facing outwards towards the west The larger and more perfect inscription was on the left (or north side) The stone itself is 2.58 meters in height, with a maximum width of 1 10 meters, and weighs 3½ tons The inscription fills 42 completed lines, 4 lines at the bottom being blank, covering a height of 141 centimeters below the sculptures on the dressed face of the stone

The Engineer in the Field

THE Marquis of Graham delivered his presidential address recently before the Junior Institution of Engineers Sir Boverton Redwood Bt in the chair He took as his text, "The War and Engineering" and remarked that war had become very largely a matter of engineering If Attila's army of 700 000 Huns were excepted no warrior had hitherto had more than 60 000 troops to transport, maneuver and maintain The Kaiser to-day boasted his four or five millions of all arms The Allies had legions equally numerous, and from each of the farthest ends of the world Britons had come in great convoys of steam transports, which dwarfed in significance the armadas of Athens, Carthage, and Rome and England of old

Referring to the movements of the British Expeditionary Forces by rail and steamship Lord Graham said that the government required the British railways to collect from all parts—north south east, and west—troops whose numbers and impediments needed 350 trains made up on an average of thirty vehicles each, and to detrain them at the ports of embarkation within forty-eight hours. This great feat was accomplished. As was now well known, most of the troops left from Southampton and for weeks trains were passed over the lines during the night at the rate of five trains per hour Such a performance was not only creditable to the organization of the railways, but proved that the mechanical equipments and direction of the port were most efficient. To tackle the troops, horses, guns, limbers, and other accessories of battalions arriving in seventy three trains within fourteen hours on successive nights was an unprecedented feat. It was right, however that similar credit should be given to the harbor authorities at Marseilles, where twenty-eight vessels with our Indian troops and their munitions of war were dealt with in twenty four hours Remarkable work too had been done by the Russian railway authorities

Motor vehicles played a great part, secretly and silently in the transfer of the British army from their trenches 100 yards in front of the enemy on the slopes in the Aisne Valley, during the night of October 20, to the new battle front on the Yser Such an unexampled strategic movement by a great army would have been almost impossible without motor conveyances in addition to railways

Great improvements had been made in guns, and the rate of fire was at least 100 times faster than of old. The German 16½-inch howitzer, firing a 1¼-ton shell, was, for transport purposes, taken apart to make four separate loads, and none of these, including the cylinder, weighed more than 25 tons. Each was hauled by three road tractors, with reserves for supplementing the tractive effort through cables and drums on inclines or hilly ground.

In the first six weeks of the war British aeroplanes flew an average distance of 2,000 miles a day, and nothing was hidden from the observer in the flying machine. For instance, an airman at an altitude of [illegible] feet above London could, if the weather conditions were favorable, see the whole coast line from [illegible] to Yarmouth, and see even the shore cliffs of France beyond.—*The Daily Telegraph.*

Monorail Electric Cranes

OF late the European electrical industry is furnishing an interesting type of monorail crane, as it is called, in the shape of an electric carriage traveling upon a structural iron beam. Such a construction will often be most convenient, especially upon building sites or within works, where space is limited and materials need to be handled rapidly over considerable distances. The [illegible] monorail carriages run suspended from the lower web of an I beam or a pair of assembled channel bars. Such a crane will answer for unloading railroad [illegible] and it takes the place of small surface cars with the advantage that no rails on the ground [illegible] are needed. To the carriage is fixed an iron frame support with seat for the operator, who works the controllers for the main motor and for the lift motor. Translation of the carriage can also be done by hand. [illegible] be noticed is that the lift motor drives the [illegible] by the recently introduced [illegible] method which we described previously [illegible] advantage of [illegible] for the [illegible] gear which [illegible] [illegible] the [illegible] method [illegible] in this [illegible] [illegible]

Wireless Telegraphy*

A Review of Some Notable Developments of the Past Year

When Sir Ernest Shackleton left England in October with the object of crossing the Antarctic continent from the Weddle Sea to the Ross Sea, he took with him a wireless telegraph station having a range of about 500 miles. Apparently it is not Sir Ernest's intention to use wireless telegraphy on his ship, but there is no doubt that it will be a valuable resource to members of the sledge party in enabling them to communicate with the base. Early in the year it was announced that the Postmaster-General had consented to a license being granted to Marconi's Poldhu station for the purpose of conducting a commercial wireless telegraph service between England and Spain. In January wireless telegraphy played an important part in the saving of life at sea, but for reasons of space we cannot do more than make a passing mention of one notable instance—that of R.M.S. Colequid which went ashore on the Trinity ledges in the Bay of Fundy. If the vessel had been unable to send out its appeal for help far and wide all on board would have been lost, for even as it was it was not easy to find the wreck in the midst of the wintry storm in a bay where the rise and fall of the tide is greatest, perhaps, than in any other part of the world, amounting to between 60 feet and 70 feet. But for wireless telegraphy it is undeniable that the situation would have been hopeless.

When the new chain of wireless stations now in course of construction by the Canadian government is finished and in operation, it will be possible for a passenger on any incoming steamship to communicate from mid ocean as far inland as Fort William. All down the river and gulf the government stations are in regular operation.

The Marconi Company has been engaged for some time in the design of wireless telegraphy for air craft and during the past year experiments were carried out at Hendon, and there is good reason to believe that the Marconi apparatus in its latest stage of evolution will meet the demands of naval and military authorities.

Finisterre, Santander, and Cape Palos must now be marked on the map of the world with a sign that denotes the existence of a wireless station. All three stations have now been in working order for some time and have been subjected to exhaustive tests by a commission appointed by the Director-General of Spanish Posts and Telegraphs. In March it was reported that the Admiralty had accepted a tender for an important extension of the naval wireless station which is situated on Horsea Island in the upper reaches of Portsmouth Harbor. Originally the aerials were 180 feet high but they are to be replaced by 400 foot aerials and the electric installation will also be improved enabling communication to be established with all parts of the Mediterranean.

In reviewing progress in 1913 we referred to some wireless telegraphy experiments made on moving trains on the Delaware, Lackawanna and Western Railroad. Further tests were made during the past year tests which demonstrated the efficiency of the Marconi system without a doubt. The railway company has completed a steel tower 402 feet high on the water front at Hoboken and has installed a 5-kilowatt high frequency set at this point. On September 19th wireless messages were received from Hoboken at the Lackawanna wireless station at Buffalo a distance of 410 miles on a wave length of 2 250 meters. A regular wireless service will shortly be commenced. The example of the Postmaster-General in deciding to substitute wireless telegraphy for the existing overland wires in exposed parts of the United Kingdom is to be followed by the government of the Commonwealth of Australia, so as to bring outlying country districts into permanent communication with all the towns and business centers. Twelve wireless installations have been established in the country districts of Queensland and New South Wales. The federal government has also decided to employ wireless telegraphy as an aid to the construction of the trans-continental railroad and to assist the operation of trains.

In answer to a question in the House of Commons on May 13th the Postmaster-General made the following interesting announcement. "A successful demonstration of wireless telegraphy at 100 words a minute was recently given by the Marconi Company between Chelmsford and Letterfrack (Galway) and it is proposed to adopt this method of working between a station which I am about to establish near Stonehaven and an existing post-office station near Newcastle-on Tyne as a stand-by in the case of the interruption of the overhead lines. High-speed transmission and reception is rapidly becoming essential to the efficient working of commercial wireless telegraph stations. By the use of such a system several telegraphists can be employed in punching the tape to feed one transmitter and thus all messages can be got through without delay and the traffic capacity of a station can be increased many times."

Although Great Britain has hitherto taken no very prominent part in the organization and maintenance of an international time service there are signs that the subject is beginning to arouse some public attention. Mr. Charles Bathurst asked a number of questions in the House of Commons on April 21st with a view of eliciting information. He pointed out that as a result of the International Conference on wireless time signals which took place in Paris in October 1912 a preliminary list of high power wireless stations organized to transmit time signals at stated hours had been issued. Although this list contained stations in every part of the world it contained no station in any part of the British Empire. Mr. Churchill who replied admitted the facts were as stated by Mr. Bathurst but he added "the British delegates at the conference made certain recommendations for the establishment of time signals at wireless stations in the dominions and colonies which would have the effect of greatly increasing the value of the scheme and I understand that these recommendations have been brought to the notice of the governments concerned." The report of the Astronomer Royal for Scotland refers to the new receiving time-signal apparatus which during the session 1913-14 was added to the equipment of the Edinburgh Observatory.

Considerable attention was paid during the year to the controlling of mechanisms from a distance solely by the aid of electric waves. Several articles dealing with this subject appeared in the *Wireless World*, one of the most interesting being on remote-controlled fog signals installed in the Firth of Clyde. With the opening of a new station at Kingston a new link was formed in the Canadian wireless chain. This station which was built by the Canadian Marconi Company, is a standard 5 5-kilowatt station. Bombay like all principal ports in the world is now fully served with wireless telegraphy equipment to meet present requirements and this has been demonstrated in the work that has been carried out at the new wireless station on Butcher Island.

The new wireless station at Carnarvon in North Wales for communication with New Jersey U.S.A. has now been completed some time and the American station or rather stations for the system employed is duplex and the transmitting and receiving stations are some distance apart—was also finished during the past year. The plant at the New Jersey stations is practically identical with that at the Welsh stations.

Farmers residing in the isolated districts of Australia have long been handicapped by the lack of means of swift communication with the outside world. Far from towns they are often compelled to put up with inconvenience and dangerous delay in the satisfying of wants and necessities. An interesting suggestion for a remedy for this state of affairs has been made by Mr. W. King Witt vice-president of the Wireless Institute of Victoria who has pointed out that the terrors and disadvantages of loneliness might be greatly reduced by the use of wireless telegraphy.

An important link in the trans-Pacific wireless chain was formed with the opening of the Marconi high power wireless stations at San Francisco and Honolulu. This is an event of world wide importance signaling as it does a further advance in the commercial development of wireless telegraphy by bringing that means of communication within range of a considerably increased number of users of the world's telegraphs to whom the reduction of cost which the wireless service makes possible in addition to its other advantages is a matter of no small moment. According to the latest Australian newspapers the authorities are making arrangements for big improvements at the different lighthouses around the coasts of Australia and new lighthouses are to be provided where necessary. The question of communication with the shore is also under consideration, and it is reported that in this connection a low power wireless system will probably come into operation. In the army and in the navy wireless telegraphy now plays an important part and is being used very extensively in the present war. Naturally this brief review only covers some of the most important developments during the past year. Wireless telegraphy advances very rapidly and a complete survey of twelve months progress would occupy far more space than we can spare.

* *The Engineer*

A Practical Fertilizer for Wartime in Germany

In the last analysis a man's ability to fight depends on the quality and quantity of his food, and these depend, if his country is blockaded against supplies from elsewhere, on the quality and quantity of the crops that can be raised at home. But of all the factors that determine the latter, that of the proper fertiliser, or plant-food, is the weightiest.

Small wonder, then, that German agriculturists, cut off from the customary supplies of Chili saltpeter, should be considering this question anxiously.

A writer in a recent number of the German journal devoted to the interests of the oxygen and nitrogen industries, *Zeitschrift für Sauer und Stickstoff Industrie*, discusses the question to much purpose. He points out that the chief fertilizers generally employed, besides [illegible] salts, are Chili saltpeter and sulphate of [illegible] the artificial [illegible], nitrate of lime [illegible] supplies only 5 to 10 per cent [illegible]

[illegible] the chief source of sulphate [illegible] there can be no lack [illegible] in price, because of [illegible]. But the writer has [illegible] of the Haber process [illegible] on the market [illegible] to such an [illegible]. He therefore [illegible] greatest possible use of other sources and to collect those fertilizers which are readily obtainable in Germany and apply them in time to prevent a reduced harvest next year.

At his instigation Herr Julius Woldering of the *Rittergut Jockedorf* has been conducting practical experiments with a fertiliser composed of finely ground calcium carbonate and coal or pulverized coke with excellent results. He says:

"An addition of about 20 per cent of fine sifted coal or coke in most cases is a good substitute for Chili saltpeter, and is, at least for a like yield considerably cheaper than all other mineral chemicals. This fertiliser of lime and pulverized coal has given extraordinary results with rye, oats, potatoes, peas, and beans. He advises that the mixture be used in stables in the winter as an underlay for the straw, in order to absorb the highly valuable nitrogenous fluids. This forms an excellent meadow fertiliser.

A very great advantage of this fertiliser is the fact that the raw materials can be hauled in wagons and mixed by the farmer himself. In localities where large quantities of sulphite lye from cellulose factories can be obtained it makes an admirable addition to the manure, but such addition requires a special method of handling, which the farmer will have trouble in doing for himself. He estimates that the cost of this lime-coal fertiliser is only 5 per cent of that of Chili saltpeter.

The crop yield is, according to the above-mentioned experimenter, at least equal to that from the usual mineral fertilizers. He also finds that the crop is sounder than that produced by Chili saltpeter which forces the growth too much. Another important feature is that the addition of carbon to the soil compensates for the gradual depletion of this element by the steady sale of the greater part of the straw each year. Also a large part of the straw used for bedding can be dispensed with. He closes by urging German agriculturists to profit by this new cheap fertiliser whose value has been conclusively proved by the scientific researches of Dr. Fischer and Dr. Bornemann.

Encouraging Tree Planting

The Massachusetts Forestry Association is making some very practical and well-directed efforts in the way of interesting towns within the sphere of its activities to undertake the work of tree planting systematically by offering a series of prizes. In four classes of towns, designated on a population basis, which win prizes for excellence in street tree planting the association will plant one hundred additional shade trees, which should be a strong inducement to any community that takes a proper pride in the appearance of its streets. The association is also encouraging town forests, and for the town that takes the first place in this work the association will award a prize in the form of fifty acres of white pine to be planted free of cost by the association. These are good suggestions that might be adopted by associations in other States.

Making Safe Steel Rails

A New Process Intended to Meet Modern Railroad Requirements

An authority on railroad matters has stated that 90 per cent of the rail failures can be divided into two general classes first crushed and split heads, and second broken bases The former are caused by excessive segregation producing brittleness in the interior of the section and the latter can usually be traced to a seam in the bottom of the base Fifty per cent of the rail problem consists in getting sound metal of even composition and 40 per cent consists in so rolling the steel as to avoid seams in the base "

These conditions have of course made themselves

Fig 1.—Face of an ingot before heating Fig 2—After heating, adhering scale removed

felt only since the weights that the rails have to sustain have increased to their present proportions and it is evident that the art of rail making has not kept up with the progress in railroad development in other directions for the facts show that merely increasing the weight of the rail does not enable it to meet the increasing demands that are being made on it If proof of this were necessary it could be furnished by the record of one road which had 2 700 rail failures during the three winter months of 1911 12 and the fact that rail failures are rapidly increasing in this country The conditions and the reasons have been recognized and attention has been called to the fact that chemical analysis of a test ingot does not furnish assurance of the condition of the finished rail and that the specifications governing the acceptance of rails are entirely inadequate

Why this state of affairs should exist is difficult to say even while recognizing the difficulties that confront the rail maker but it is gratifying to see that at least one concern is taking active steps in seeking a remedy as described in the following paper read by Mr Robert W Hunt before the American Society of Mechanical Engineers which is here reproduced from the *Iron Age*, but it may be noted that one of those who discussed this paper made the very direct suggestion that the remedy cured something that ought not to exist

Increased weight of rolling stock and speed of traffic have necessitated increasing the size of the rail sections, and hence their weight, and as many of the details of rail manufacture have been changed with such alterations, it is not surprising that new and unexpected physical weaknesses developed in the heavier rails One of the most notable was failure through crescent-shaped pieces breaking out of the rail flanges followed by at least one, and in many cases several ruptures across the whole section of the rail Investigation showed that in practically every instance of such failure there was a more or less pronounced seam running longitudinally in the bottom of the rail near its center and thus immediately under its web This seam occurs at the top of the curve of the crescent-shaped break and it is undoubtedly the point at which the fracture starts

It is true that rails with actual flaws in their flanges have been rejected as first quality ones and that a very pronounced seamy condition of the bottom of the rail would also cause its rejection Such rejections were the cause of frequent disputes between the mill operatives and the inspectors the point being as to how far the inspectors were warranted in carrying their condemnation but as already said it was not felt that a single seam unless very pronounced would be dangerous

The crescent-shaped breaks were of such frequent occurrence that they indicated a very serious condition and led rail makers to experiment with the design of their rolling passes with a view to obviating the formation of the bottom seams It was found that fewer seams were produced by such changes but they were not entirely eliminated While more or less successful in preventing the formation of seams through lapping on the bottom of the rails the formation of seams in other parts of the section was not particularly affected

T H Mathias assistant general superintendent of the Lackawanna Steel Company determined that the most certain way of getting rid of seams was to remove that portion of the metal which contained them and as applied to steel rails thus to eliminate them from both the base and head of the rail This was a reasonable assumption but its execution I think would have seemed very impractical to most metallurgical engineers Mr Mathias reasoned that the primary causes of seams existed previous to any rolling of the steel in fact were incident to the casting of the molten metal into ingots He knew that disk-like apertures were formed on the sides of ingots while the molten metal was being cast and were probably caused from air being entrapped against the sides of the ingot molds by the hot steel as it rose in the molds a condition which was not controlled in regular manufacturing routine This condition is illustrated by Figs 1 and 2 which are photographs of the same face of an ingot Fig 1 showing the side as it would appear before heating while Fig 2 shows it after heating with the adhering scale removed Fig 3 represents the actual size of a section of a face of such an ingot, and gives an illustration of how serious such apertures may be It will be appreciated that, as the section of the ingot is reduced and elongated in the rolling process, so, of course, will the apertures be stretched longitudinally and thus be formed into seams.

Mr Mathias demonstrated that there is another constant condition present in the rolling of large steel ingots, in the formation of a decarburized surface on all of their four faces about 5/16 inches deep, and containing from 8 to 10 points lower carbon than the metal immediately under it, the decarburized envelope undoubtedly being produced through the oxidizing conditions to which ingots are subjected in the soaking pits where they are heated preparatory to rolling A thick oxide scale is always formed on the surface of ingots in the pits, so that conditions are invariably present for the production of such

Fig 3—The milling tool

a layer of lower carbon metal on their outside faces, Fig 4 illustrates the presence of this lower carbon envelope or skin It shows a polished and etched cross-section of a part of an ingot which has been heated to a rolling temperature in the soaking pits but not rolled, from which it will be realized that ingots of large section have both disk-like apertures on their four faces and a decarburized envelope in which they are contained.

Mr Mathias was convinced that during the process of rolling ingots into rails it was practical to remove mechanically the parts of the enveloping steel which would form the top of the head and bottom of the flange of the rail and experimented accordingly He designed and his company installed as an addition to their rail train, a milling or a hot sawing machine, as I believe Mr Mathias designates it to cut off hot metal without retarding the regular operation or thus interfering with the production of the mill This is illustrated by Fig 5 which is a photograph of the machine in operation. The machine is located in echelon in relation to the rest of the rail train.

The ingot is reduced in the blooming rolls to an 8 by 8 inch cross-section and after cropping the ends the bloom is further reduced in the roughing or shaping stand of rolls by five passes When it leaves these rolls, it is approximately 75 per cent finished and at this period it is carried to the right and entered between two pinch rolls with its base or flange side up A bar which will make four 33-feet rails is at this point in the rolling operation about 60 feet in length, therefore, the area of metal to be cut off or removed in the milling machine is approximately ¼ inch deep, 7 inches wide and 60 feet long It is driven through the pinch rolls at a rate of 60 feet in 30 seconds The pinch rolls have a draught of about ¼ inch and thus force the bar between the two milling saws, which are so arranged in the housing that they may be raised or lowered as desired From 1/32 to 3/64 inch of metal is milled from the head and base of the bar, the front end of which, immediately on passing from between the rolls, is caught by a second set of pinch rolls which have a draught of about 1/16 inch. These pinch rolls force the bar between the tools, pull it from between them, and also hold it in practically perfect line for the milling operation. The milling apparatus is driven [illegible] and requires about [illegible] horse-power for its operation.

Fig. 6 shows an etched cross-section of the [illegible] preparatory to its entering the milling machine, [illegible] it is clearly [illegible] the enveloping layer of lower [illegible] steel.

As the [illegible]

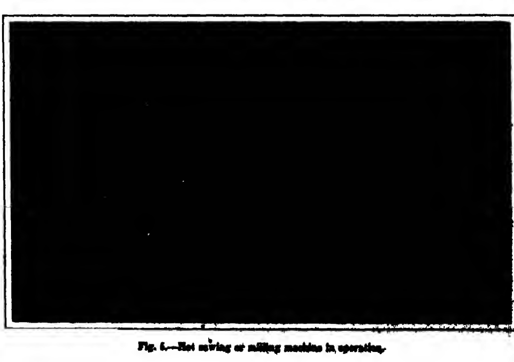


Fig. 5.—Hot sawing or milling machine in operation.

Fig 3.—Section of face of ingot, full size

7 shows the condition of the accumulated material which is in regular open hearth furnace charging boxes

Fig 8 shows one of the milling tools It is 5 feet in diameter with an 8-inch width of face and revolves at a peripheral speed of 2 500 feet per minute thus causing an engagement of about 400 000 teeth per minute on the hot rail bar The teeth are of 0 80 carbon steel and it has been demonstrated that they will mill at least 30 000 tons of material without requiring dressing The one shown had milled about 15 000 tons

Fig 9 presents the shape of the bar after it leaves the milling machine preparatory to further reduction in the regular rail rolls It will be noticed that the milling on the flange has not reached the extreme edges of the bar and on the head side has not affected the corners, and it will be recalled that Fig 8 showed the milling tool with a straight face It is apparent that either by a modification of the shape of the piece as presented for treatment in the milling machine or what will probably be more practical changing the face of the tool the milling can be extended to the extreme edge of the flange portion of the bar and somewhat around the corners of the top or head side This will undoubtedly be perfectly practical and thereby eliminate the seams which may be located in these parts of the bar Such elimination is not accomplished at present and perhaps it may not be necessary The primary object was to eliminate the seams from the central portion of the bottom of the rail which had been the starting point of the moonshaped failures and to remove them from the top or bearing surface of the head of the rail Personally I think it will be desirable to extend the milling by the use of concave-faced tools

The work of rolling which the steel receives after the removal of the more or less laminated metal must produce a better product than if such elimination had not taken place and in the case of steel rails it should not only make them less liable to breakage on account of seams in their flanges but also enable them better to resist the abrasive effects of traffic

During the many years of my connection with rail making I have examined a great many etched specimens of rails not only directly in connection with the process under consideration but for various other reasons From such experience I can fully appreciate what Mr Mathias has accomplished The surfaces of practically all rails when etched will show some seams on both base and head and very frequently the extent of such defects will not be appreciable if the scale has not been removed Even then it is not always an easy or certain matter to estimate the depth of the seams When the rails have been subjected to the Mathias milling operation and still show pronounced seams it has been found that breaking tests will practically always develop the fact that the suspicious marking is an actual seam

To illustrate the appearance of many ordinary steel rails of commerce when etched Figs 10 and 11 show the surfaces of both heads and flanges These specimens were taken from rails made by several different makers, including the Lackawanna Steel Company These illustrations not only clearly show the field for such an operation as I have described but also the extent to which Mr Mathias has been able to accomplish it

While I have confined myself to the matter of steel rails it is patent that the process will be of great value in the preparation of blooms for axles and all other kinds of forgings As is well known it is practically the universal custom to endeavor to remove the seams developed in rolling axle billets by chipping them out through the use of pneumatic hammers and for some of the higher characters of forgings notably for automobile parts, the endeavor to eliminate the seams is carried to the extent of turning off the whole surface of the billets. I am confident that by the Mathias plan the greater part if not all of such work can be superseded

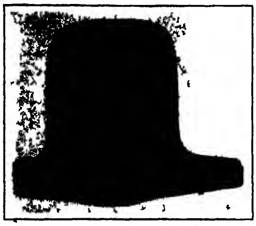


Fig 6.—Cross section of bar before entering machine

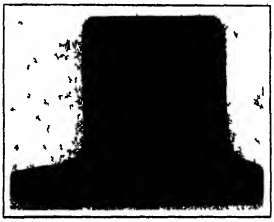
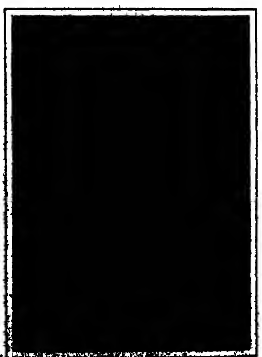


Fig 9.—The bar after it leaves milling machine

Fig 4.—Etched surface showing lower carbon skin of ingot

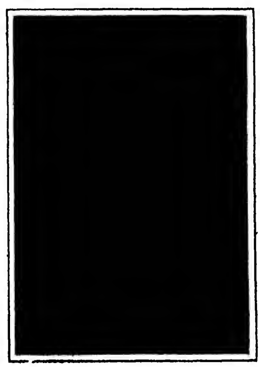
Top surface



[illegible]

Fig. 7.—Cuttings produced by milling.

Top surface



Bottom surface.

Fig. 11.—Milled rail.

Waste in Hiring and Discharging Employees*

A Discussion of an Important Industrial Problem

By Magnus W. Alexander

It has pleased your President to style as an address what I wish to present to you in an informal way in reference to an investigation into the economic waste of unnecessarily discharging employees I have not heretofore spoken publicly on the subject and have unsuccessfully tried to dodge it at this time mainly for the reason that in order to give proper background to the statements which I desire to make I ought to present corroborating figures and facts but cannot do so without divulging information given to me confidentially by a number of manufacturing concerns throughout the country I shall be obliged therefore to use as illustrative figures aggregate statistics of several concerns rather than concrete examples of individual employments

Everyone who is an executive knows how disheartening it is in industrial life to be obliged occasionally to dismiss employees in obedience to business conditions and not at all on account of any fault of such employees Disregarding the personal and human aspect of the problem and looking at it solely from the cold business standpoint it is at once clear that every unnecessary dismissal of an employee means a definite economic loss to the employer If through the adoption of different methods than are now in vogue this economic waste can be prevented either in whole or in part it becomes a duty of the employer to himself and to his employees to re-arrange his methods of employment in accordance with improved standards Many employers have recognized the truth of this statement and have found it profitable to maintain specialized employment departments in charge of competent managers They know from experience that it does not pay to hire and discharge haphazardly they realize that it costs money to train an employee even a skilled workman in the special practices that are peculiar to a given concern and that the dismissal of an employee except for good reasons means that the expenditure for his training has gone for naught and that an additional expense must be incurred in the training of a new employee

Appreciating the situation I have given some time and thought to this subject and will present to-day an outline of my findings I hope at the same time to make employers recognize more fully than they have in the past the importance of this phase of economic management

A great deal has been said in the last few years and properly so about reducing the cost of production through so-called scientific management which endeavors to eliminate every unnecessary motion and every unnecessary expenditure Hand in hand with if not even preceding this effort should go a well-directed endeavor for a closer analysis of the men whom we take into our employ of the systems under which we train them in our work and of the reasons for and the methods under which we let them go only to have their places filled again by new recruits

My observations were concerned with large medium size and small manufacturing concerns throughout the United States all of which form a part of the mechanical industries During the summer of 1913 while in Europe I made similar investigations in factories in Austria Germany France and England Information and statistics from these European factories would indicate that the problem under discussion is not only a national but an international one it is so much the more surprising therefore to find that it has received so little serious attention by sagacious business men on this and the other side of the ocean

The investigation endeavored first to trace the curve of engagements and discharges in the various concerns during the period of one year and then to secure and study the reasons for the discharges in order to find if possible practical remedies for the resulting situation All data were obtained for the year 1912 which may be considered to have been an industrially normal year

The investigation covered the employment and discharge of all classes of employees at the various factories except those belonging to the commercial and engineering organization and to the general executive staff A record of those who had entered the service of the concerns for the first time and of those who had been working in the same place at a previous period was also obtained for it was assumed that re-employment would usually cause a smaller expense than the employment of entirely new people unfamiliar with the conditions prevailing at a given factory

For the group of factories for which I shall present figures in the aggregate it was found that of all people engaged during the year 1912 about 73 per cent were entirely new employees and correspondingly about 27 per cent were re-engaged employees As a general proposition this percentage will apply fairly well to any normal employment in the mechanical industries

The group of factories just alluded to, covering the employment of male and female persons and a great variety of mechanical manufacture requiring labor ranging all the way from the highest skilled to entirely unskilled workmen gave employment to 38 668 employees at the beginning and 46 796 employees at the end of the year 1912 *The increase in the working force as between January 1st and December 31st, amounted therefore to 8 128 people Yet the records show that during the same period 44 365 people were engaged indicating that 36 237 people had dropped out of the employment during the year for whatsoever reason* In other words about 5½ times as many people had to be engaged during the year as constituted the permanent increase of the force at the end of that period

Several reasons might be given in explanation of this condition It might be stated that the labor market in a given locality was in part responsible for the situation it might be claimed that in a particular plant a temporary piece of work had to be done, such as the digging of a foundation or the building of a structure for which labor in excess of the normal quota was needed temporarily to be dispensed with again when the special work was finished Unusual conditions of employment may be pointed out as the result of a highly fluctuating productive situation brought about in turn by a largely varying commercial demand on the factory during the four seasons of the year Finally sight must not be lost of the fact that some people die others drop out on account of prolonged sickness and still others leave the employment for reasons that could not have been obviated by the management

The important fact, however stands out that 44 365 people had to be engaged during the year to retain less than 20 per cent of that number

Theoretically only as many people ought to have been hired as were needed permanently to increase the force As business men we know however that theoretical conditions do not surround our commercial enterprises and that we must make certain allowances in order to view the problem in its practical aspect Accordingly we must admit that

(*a*) Men die and must be replaced

(*b*) Men leave on account of sickness for sufficiently long periods that their places must be filled by others

(*c*) Men even though they have been selected for their positions with good judgment leave of their own accord because they do not find it possible to remain in their new positions whether on account of climatic conditions domestic affairs or other reasons necessitating their removal from the locality

(*d*) Finally it must be recognized that no employment department can run on a 100 per cent efficiency basis

Taking these items into account it must be clear that more than X people will have to be hired during a year in order to increase the working force by X persons. In an attempt to assign values to the four causes just enumerated I have assumed that annually

1 per cent of all employees die,

5 per cent leave on account of prolonged sickness,

10 per cent withdraw for reasons that could not have been foreseen at the time of their engagement, and

75 per cent constitute a readily attainable efficiency of an employment department

These figures find their support in the following considerations

After ascertaining the average age of employees in the group of factories under investigation, namely 31½ years for male and 28 years for female employees, I turned to insurance statistics and found that 8 5 out of every 1 000 male persons of 31½ years of age and 7 95 out of every 1 000 female persons of an average age of 28, engaged in general factory employment, die annually The experience of several mutual benefit associations in factories some extending over a period of almost 10 years revealed that annually almost 7 in every 1,000 members were removed by death. These statistics, then fully corroborated my assumption that death removes 1 per cent of factory employees annually.

Insurance statistics also show that about 2 per cent of average factory employees are sick annually for periods of two weeks or more, this percentage drops considerably when sickness of three weeks' duration or more is taken into account. Again, the experience of mutual benefit associations fairly well agrees with the data of insurance companies. Knowing, however, the prevailing custom in most factories to carry on sick leave for much longer periods than two weeks those of whose sickness the management has definite knowledge, I have assumed that 5 per cent of all employees will have to be replaced on account of prolonged sickness and consequent withdrawal from the service

As to the number of people who withdraw during the year for whatsoever other reason, except that of sickness and death no reliable experience seems available. In fact the only information that I could find is that contained in the United States Civil Service report, according to which 8 per cent of all government employees are separated from the service annually for any reason, including that of sickness and discharge. Realizing, however, that governmental employment conditions are different from those in industrial establishments, I have doubled the government estimate by allowing 16 per cent for withdrawal by death, sickness and resignation, or 10 per cent for withdrawal by unavoidable resignations alone

Finally, I believe that a 75 per cent efficiency of an employment department and even a greater efficiency should readily be attainable in a highly specialized department in charge of one or a few persons.

It follows therefore that while theoretically 8,128 people should have been employed to allow for an increase of the working force by that number, 11 825 persons should have been engaged in addition to cover withdrawals by death sickness and resignation, and to allow for practical employment results If we take cognizance furthermore of normally fluctuating productive conditions necessitating at times more and at times less employees, and of unpreventable exigencies of the labor situation, we could make a further allowance of 2 187 persons, representing 5 per cent of the total working force throughout the year

While theoretically, therefore, only 8,128 persons should have been engaged practically the engagement of 22 140 could readily be defended

What should be said, however, of the fact that in order to increase the force during the year by 8 128 44,365 total had to be engaged of whom 22 225 were therefore engaged above the apparently necessary requirements?

It is obvious that a considerable sum of money must have been wasted in engaging and correspondingly discharging unnecessarily so large a force of men and women. In order to secure a lucid picture of this fact I have tried to assign a dollar-and-cents value to the figures just quoted No reliable investigation seems to have been made and published in respect to such financial valuation Industrial managers were therefore, interviewed in an effort to obtain from them if possible a consensus of opinion They were rather loath to express their views because they had not given heretofore serious thought to the question. Their estimates ranged from $30 00 to $150.00 per employee, few placed the financial valuation of the waste at less than $50.00 per employee and some went even as high as $200 00 per employee. The great difference in these estimates is no doubt due to the diversity of the industries which these managers represented

One machine tool builder, who is usually very keen in following up matters of this kind, after they have been called to his attention, looked into the subject with some care and stated it as his belief that the engagement of almost 1,000 persons in his plant during one year, while the permanent increase in his force [illegible]

*Delivered before the National Machine Tool Builders Association New York City

[illegible] new employee has much bearing upon the amount [illegible] that needs to be expended for his training [illegible] important consideration is whether the new [illegible] is working on expensive or low priced machin[illegible] with high or low priced tools, or on expensive [illegible] material; and to a certain extent whether or [illegible] having been employed before in the same shop and [illegible] on the same class of work.

This thought led me to subdivide the employees under investigation into several groups and to study each group as to its requirements for the training of an employee both as to quantity and quality of the instruction. Accordingly, I established the following classes

Class A, comprising highly skilled mechanics who must have practised their trade for a number of years in order to attain the required high degree of all-round [illegible] and proficiency,

Class B, comprising mechanics of lesser skill and experience, who likely could acquire an average degree of proficiency within a year or two,

Class C, composed of the large number of operatives usually known as piece workers who without any previous skill or experience in the particular work attain efficiency within a few months, depending on the character of the work.

Class D including all unskilled productive as well as [illegible] laborers who can readily be replaced in the course of a few days and

Class E, comprising the clerical force in shop and office

The employees assigned to each class were again subdivided in the ratio of 73 per cent to 27 per cent to separate those that may be assumed to be entirely new recruits from those who may be considered to have had previous experience in the same factory

On this basis, the following distribution of the employees was obtained

In Class	Total Engagements			Unnecessary Engagements		
	All	New	Old	All	New	Old
A	4 961	3,563	1,818	2 445	1 785	660
B	6 519	4 759	1 760	3 205	2 334	871
C	15 087	11,014	4 073	7 558	5 517	2 041
D	14,905	10,881	4 024	7 467	5 451	2 016
E	2 973	2 170	803	1 489	1 087	402
All	44 365	32 387	11 978	22 225	16 224	6 001

The next question is What factors mainly contribute to the cost of training a new employee?

This cost may be considered to result from

(a) Clerical work of hiring,

(b) Instruction of new employees by foremen and assistants,

(c) Increased wear and tear and damage of machinery and tools,

(d) Reduced rate of production during early period of employment, and

(e) Increased amount of spoiled work by new employees

The expense of the clerical labor of hiring will be small per individual, somewhere in the neighborhood of 50 cents for each employee.

The instruction expense, on the other hand will vary largely in amount according to the skill and experience of the new employee and the nature of his work It will be lowest for Class D and highest for Class C employees for the latter must be instructed most and watched longest Without now taking the time for a detailed explanation of the conclusions, I feel justified in assigning the following expense values, to wit

Per Employee

Class A	$ 7 50	Class D	$2 00
Class B	15 00	Class E	7 50
Class C	20 00		

The value of the increased wear and tear and the damage of machinery and tools by new employees is difficult to estimate It will be little if anything for Class D and E employees, for which it may be presumed [illegible] per employee. It may reach thousands of dollars for damage to expensive machinery in the keeping of Class A, B, and C employees for whom an amount [illegible] would be very reasonable

The loss due to reduced production is entirely dependent upon the value of the produced article and the [illegible] and skill required for its production. On the basis of some investigation as to how soon employees in the various classes are able to reach normal productive [illegible] in a factory new to them, and with due regard [illegible] average [illegible] I have assumed the loss [illegible]

Per Employee

[illegible]	[illegible]	Class D	$ 5 00
[illegible]	[illegible]	Class E	20 00
[illegible]	[illegible]		

[illegible] spoiled work, which [illegible] and the latter [illegible] for each Class A, B and C employee and practically nothing for Class D and E employees

The respective totals of these items show that the cost of training new employees amounts to the following

Per Employee

Class A	$48 00	Class D	$ 8 50
Class B	58 50	Class E	29 00
Class C	65 50		

Bearing in mind the assumption that about 27 per cent of newly engaged employees had worked before in the same factory the cost of their new training should be considerably reduced even though this reduction would seem justified only if the employee were put back on exactly the same class of work upon which he was previously engaged A conservative estimate would place the expense of breaking in re-hired employees at $10 00 in Class A $20 00 in Class B $35 00 in Class C $5 00 in Class D and $10 00 in Class E for each such employee

Out of these considerations grows the astonishing conclusion that the apparently unnecessary engagement of 22 225 employees within one year in the group of factories under investigation involved an economic loss of $774 139 00

This means that the cost of training a new employee taking all in all amounted to $34 85 or about $35 00 which not only comes within the range of estimates heretofore mentioned but brings the figure practically near the lower limit of the estimates

This important question immediately arises How can this unnecessary loss of about three-quarters of a million dollars be avoided in future if not entirely at least in part?

Five answers present themselves readily

1 An adequate study of current employment statistics and a careful analysis of the reasons for the discharge of employees will furnish a fact basis of great value

2 High-grade men must be placed in charge of the hiring departments of concerns

3 The exercise of proper methods for the taking care of new employees is an exceedingly important problem

4 Effective systems of apprenticeship and specialized training courses must be maintained and

5 Commercial requirements should be so regulated as to secure a fairly uniform productive situation throughout the year

It should be unnecessary to point out that the reasons for the voluntary or involuntary leaving of an employee as given by the foremen on the discharge cards cannot be fully relied upon and that special effort should be made to get at the real reason for an employee's discharge so as to secure a correct basis on which to build remedial action

In the light of the above statements and figures it should also be unnecessary to defend the necessity for the highest grade of judgment in the hiring and discharging of employees The employment clerk of to-day will have to be replaced by the employment superintendent or manager of to-morrow not merely by changing the title of the man but by changing the type and character of the man even though this will mean a higher salary Second in importance to the manager of the plant should be the assistant who is entrusted with the duty of bringing into the plant the men and women that are needed from time to time and of keeping them there contented and efficient What methods to employ to take care of employees from the very moment when they start in their new work is a far more important question and presents a far more difficult problem than that of the proper selection of new employees from among the applicants for the job The very best thought on the psychological side of industrial management will have to be applied to this particular phase

It has been recognized for some years even though not perhaps as fully as should be that it is the duty of industrial managers so to take hold of the youth of the land and properly train the boys and girls who wish to or by circumstances may be obliged to choose a vocational occupation for their livelihood, that they may become intelligent skillful and contented workers and leaders in our constantly growing industrial army Although to a certain extent all managers take an interest in this problem of providing an adequate supply of properly trained workers, many have not yet discovered that it will be essentially worth while to set aside the required time from their busy life and to devote appropriate effort and financial support to this issue

As for the last suggested remedy to bring about a more evenly arranged production throughout the year, I can only express the belief that much good to all concerned can be accomplished in this respect, and I am encouraged in this feeling by the growing examples of standardization of product which brings with them ability to manufacture for stock as well as for immediate delivery, thereby permitting the maintenance of a fairly even production throughout the year

Along the five lines of remedy herein suggested lies, to my mind the solution of a problem which looms large before our eyes and will loom larger as competition will grow keener The Man problem as contrasted with the Material and Machine problems will and must in future engage more fully and more keenly our best attention

It is somewhat reassuring at the present time although it may not remain so for long to know that the conditions of employment herewith presented do not seem to be any better in European industrial countries Merely in support of this statement the following illustrations drawn from factory experience in Germany and England may be of interest

Factory	Employees at Beginning of Year	Employees at End of Year	Total Increase During the Year	No Persons Hired
1	13 556	16 450	2 894	9 530
2	10 998	11 914	916	17 059
3	9 165	12 032	2 867	10 982
4	3 158	3 149	Minus 9	2 148
5	365	470	105	637

In presenting to you the results of my investigation into the waste of hiring and discharging employees I have made no effort to paint a black picture but have merely presented the varied colors of the industrial spectrum I have pictured what seems to be an average condition throughout the country Time has not permitted to place before you a detailed analysis of the contributing causes and remedial actions for the problem under discussion however a word to the wise is sufficient

I now close with an earnest plea that you give the problem careful consideration and indulge in similar investigations in your own factories to assure yourself of the state of your affairs and where necessary to correct unsatisfactory conditions It will also give you a more concrete knowledge of the subject so that a future discussion of it may be conducted with a more assured hopefulness of finding and applying the right remedy or remedies for an unsatisfactory situation Through a correct solution of the problem we shall not only contribute materially to the welfare and prosperity of the industries but also to the contentment and well being of the thousands and thousands of employees who cannot be benefited in any degree by short-time and haphazard employment

In view of certain legislative and administrative tendencies now affecting American industries it is important also to reflect that constant fluctuation in the working force of an establishment must materially increase the difficulty of maintaining among the employees loyalty to the management esprit de corps and general contentment Just as little as we shall be able to take quicksand and knead it in our hands into a solid lump so also will we find it impossible to take hold of an ever-changing mass of employees and transform it into a homogeneous intelligent contented body furthermore this condition will nullify to a large degree the beneficial effect of many well intentioned efforts of the management such as sickness and accident insurance plans pension systems and other phases of industrial betterment work

And last but not least *the problem of employment offers an opportunity for constructive work in which employers and employees can readily be brought together for mutual benefit* for no right-thinking man whatever his position can justly object to any well-directed plan which will give employees continuous work through ut the year and will enable employers to maintain steady production

Properties of Selenium

An extremely interesting report of an investigation of the crystal forms of metallic selenium by Mr F C. Brown recently appeared in the *Physical Review* In this research a large number of new crystals of metallic selenium were formed, some of very large size. All of these forms, except one, are very transparent selectively to light, a large amount of light penetrating to a greater depth than 0 2 millimeter All the crystal forms increase in conductivity when illuminated and with but one exception they have been observed to be doubly refracting. The action of light is in the selenium itself and not at the contacts. Mechanical pressure produces a genuine change in the selenium, which may alter the conductivity more than a thousand times. The absolute change of conductivity in one crystal by constant illumination was proportional to the conductivity in the dark, when that conductivity was altered by pressures between 1 atmosphere and 180 atmospheres. The temperature at which the crystals sublimate in mass influences the character of the wave-length sensibility curves. The production of individual crystals of metallic selenium of large size opens up a wide field of investigation which promises to be free from some of the possible complexities in selenium cells.

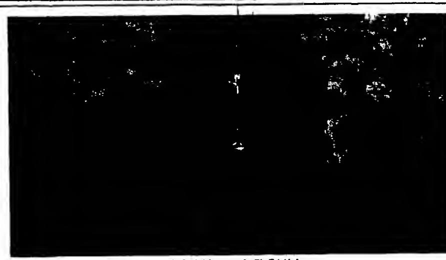
The common method of navigation of small streams by the native Panamanians is by means of the cayuca or dugout, which varies in length from eight to thirty-five feet, and is cut from a single tree. These boats are used by the natives for bringing fruit and produce to market, and it is a common sight to see them loaded with sugar cane cut in sections eight or ten feet in length.

The low entrance to limestone cave on the Chilibrillo River opens into a series of long corridors and chambers more or less intercommunicating.

Waterfront of Panama City, where the boats come in to market, in the early morning, loaded with fruit and vegetables from the neighboring islands.

Flashlight of small cluster of bats before alarmed.

Clusters are ordinarily formed of a great number of individuals, probably several hundred in some instances. The variety shown is one of the largest of South American bats, one specimen secured having a wing expanse of twenty-six inches. The bats are strong and muscular and always ready to bite. The masses of bats bear close resemblance in form to the stalactites with which the walls and domed ceilings are covered.



Newly flooded forest on the Rio Trinidad.

Rivers in the Gatun region have risen, as this photograph indicates. The lake of the region, previously a negligible one, has now an extent of one hundred and sixty-four square miles and a depth in places of seventy to eighty feet. In the photograph an iguana can be seen on the upright stump and a white egret on the log at the center.

In a bat cave.

Showing method of photographing bats by flashlight. As the flashlight powder used is exceedingly explosive the expression of apprehension on the face of the operator is not to be wondered at.

The black howler, the largest of the Panamanian monkeys, is looked upon by the natives as a weather prophet, its loud, long, and reverberating howl being most frequently heard just preceding a heavy rain.

Flashlight photograph of one of several varieties of opossums encountered in the Canal Zone.

The particular opossum shown is the commonest species and by reason of its abundance and its omnivorous appetite, it proved a serious obstacle to flashlight photography. Probably seventy-five per cent of the flashes fired were sprung by opossums who found and fired the camera shortly after dusk before better game was moving.

Flashlight photograph of bats.

Although these caves were inhabited by several different species of bats, it was found that, for some reason not clearly apparent, each species isolated itself in a particular grotto. Not only this, but the different sexes of each species was found similarly separated and isolated.

Flashlight picture of paca (Agouti paca virgata), one of the largest of the existing rodents, the closely related carybara alone exceeding it in size.

The paca is an animal of nocturnal habits and, therefore, can be photographed only by means of flashlight apparatus set at night. Note in the animal's mouth the mango which was used as bait. This is one of the game animals of the natives who call it *conejo pintado* or spotted "rabbit."

It was because of the flooding of the Gatun Lake basin by the huge dam at the Gatun locks, thus causing abrupt changes in the faunal conditions, that an expedition under the patronage of Mr. George Shiras, 3rd, was undertaken. The houseboat formed the base camp from which trips were made by launch or small boat, sometimes along rivers which heretofore have been inaccessible owing to shallow water. The houseboat had sides of cheese cloth and copper screen to keep out mosquitoes.

Scene on the Rio Chilibrillo up which trips were made to visit the bat caves.

As palms never grow in water, something of the extent of the flooding of this region can be judged.

Lake end of Gatun locks looking out over Gatun Lake.

Three different stages in filling the locks are shown, the lock at the left being empty, the one in the lower right-hand corner half full and the one in the upper right hand corner full. Emergency dams are seen in the background. Four locomotives similar to the one shown are to be used for each ship, two being in front and two in the rear.

Views in the Panama Canal Zone Secured by the Expedition Investigating the New Faunal Conditions Since the Gatum Lake Was Created

New Faunal Conditions in the Canal Zone

Notes of an Expedition to Investigate the Results of the Physical Changes in this Region

By H. E. Anthony

During the months of February and March of last year it was the good fortune of the author to accompany, as an American Museum representative, Mr. George Shiras, 3rd, on a trip to the Canal Zone. Mr. Shiras desired to obtain photographs by flashlight of the animal life of that region, a method of which he is one of the foremost exponents to-day and which has yielded him some remarkable results in temperate regions. It was through his generosity that the Museum was able to send a collector to Panama with him.

It was expected that faunal conditions in the Canal Zone would be undergoing abrupt changes because of the damming of Gatún Lake and the consequent extensive high water. From a basin with no lake worthy the name, with standing water confined largely to marshy areas except during the height of the rainy season, the Gatún region has been transformed by the huge dam at the locks into a lake of one hundred and sixty-four square miles in extent and a depth of seventy to eighty feet in many places. This flooding of ground formerly high and dry, it was anticipated, would drive many animals to seek new homes or might even threaten some of the more restricted, lowland-living animals with extermination. Incidentally many of the islands and ridge crests left above water might have a concentrated fauna driven there from the adjacent flooded localities. Other phases of the question dealing with the newly created lake were the wiping out of the lowland forests by submergence, the rise of new aquatic flora, such as the water hyacinth, and the probable inhabitation of the lake by water birds. Such were some of the items in the purpose of the expedition and we were equipped to take advantage of these new conditions if the foregoing assumptions proved correct.

As Gatún Lake was the center of investigation, it was planned to work from a house boat as a base camp, with a launch and small boats for side trips. Accordingly a boathouse was made over by a few alterations, but only after considerable time had been spent in trying to secure something available for the purpose. The house boat was so low in the water that she could be towed only in a calm sea, a condition of the lake only rarely met with, and at best the launch could make but slow time pulling her. Late afternoon of March 6th saw us leaving Gatún with the house boat and by 3 o'clock the next morning we were tied up at the head of a waterway or *trocha* that branched off from the Rio Trinidad. This was our main camp and we hoped to be able to work the undisturbed jungle from here. Unfortunately, a plantation nearby, a young fruit district only recently made accessible by high water, chose this time to burn over some clearings, and we found that the smoke materially interfered with our success. Cameras with flashlights and bait were set out in promising spots, lines of traps for mammals were run daily, while the jungle was hunted in hopes of shooting specimens.

It was at this spot that we made the acquaintance of the largest of the Panamanian monkeys, the "black howlers." Frequently their queer booming, roaring howl echoed through the jungle, a call that carries for long distances. They howl oftenest just before or during a rainstorm and the natives thus look upon them as weather prophets. Upon one occasion I stood almost under some trees through which a troop was passing, while the first big preliminary drops of a sudden shower pattered upon the leaves about me. The volume of sound that issued from the black shaggy throats was so great and so suggestive of a large animal, a lion for example, that I found it hard to reconcile myself to the actual facts. I felt a pang of regret at silencing one of the "howlers," but as a specimen was needed I shot one of the foremost and heard him crash through the limbs to the ground. Pangs of a more effective sort were experienced when my native boy and I attempted to retrieve the monkey, for he had fallen underneath a bees' nest the size of a bushel basket and we found the nest too late to avoid it.

Other interesting mammals encountered here were the pretty squirrel-like marmoset, the short-haired anteater and several species of opossums, while we were continually wondering at the variety of the bird life and the diversity of the bird songs and callnotes. The noisy parrots that shouted in the morning until the jungle rang with their tumult, the grotesque toucans which at times vied with the parrots, the calling of the parrakeets, and the peculiar chorus-like calls of the chachalaca, or "wild turkey," produced an impression that must ever be associated with jungle memories. At night mysterious noises were heard from unknown sources, and one weird laughing call in particular caused conjecture to run rife, there being as many opinions as there were listeners.

Besides the work done on the Rio Trinidad, several long trips were made by launch far up the river as the launch could ascend and two others up the Rio Chilibrillo to some limestone caves for bats. On these trips it was found that the rising waters had ascended far up the river valleys, which in this part of the region have very little fall, making them navigable to launches where formerly it would have been impossible to take a cayuco or native dugout. Some of these flooded rivers—rivers by courtesy, for in the States these streams would be called creeks—with their banks densely lined by jungle vegetation which met overhead and dropped long vines and streamers into the waters, were very beautiful.

Everywhere we found the forest inundated. In regions early flooded, where the trees were submerged for the greater part of their height, all the trees were dead and leafless with an occasional great clump of orchids, the only green left. Many square miles of the surface of Gatún Lake are thickly studded with dead tree-tops of what was at one time splendid tropical forest. In regions of later high water many of the trees were still green and blossoming; especially was this so along the shores where but the lower part of the tree trunks were under water. It is not improbable that some of the more resistant trees may live to a ripe old age with their roots some feet below the surface of Gatún Lake, for some species were found flourishing among their long since dead companions. No new aquatic growth, arisen to take advantage of the altered conditions, was noted, but the conditions had probably not been in operation long enough to bring about such a growth. The dead trees are constantly falling and the far-reaching crash of their descent is one of the common sounds of the lake.

Gatún Lake will undoubtedly produce new economic conditions among the natives of the adjacent district. These natives formerly had no other waterways but the few rivers that traversed the interior basin, and were available for navigation only to a limited number of villages. Such rivers were the Chagres, Trinidad, and Gatún. Now the far-extending lake shores provide such an accessible waterway that the natives are learning to navigate on lake waters, and every morning their *cayucos* may be seen lined up at the native market along the lock-front at Gatún. Being primarily river boatmen, however, they are yet somewhat distrustful of the lake winds and do most of their traveling at night when the winds die down. During the dry season, from January to April, the winds blow across the lake toward a northern quarter of the compass, and just the reverse holds true for the rest of the year. This wind at times becomes strong enough to threaten small boats seriously, and at practically all times of the day would be a strong check on the progress of the native dugout that was facing it. We found it necessary to move the house boat always at night and in the early morning hours because of this wind, and this proved a serious obstacle to working many localities, because it was out of the question to run at night without a moon, and when we most wished to move we had a late rising moon. After driving the launch full-tilt over a floating tree and into partially submerged bush and tree tops, trying to steer by lantern light, we confined our future movements to moonlit hours.

Whenever one left the waters of Gatún Lake the dense, unaltered jungle was at once encountered and no matter how much its beauty was to be admired from the boat, its impenetrability was no less to be deplored. It was useless to attempt to leave the trail without recourse to the *machete*, the long brush knife of Latin America, and many were the varieties of briars and thorns to be avoided. Once into the thick growth of the jungle, the hunter found it necessary to stand [illegible] in one spot in order to look into all the arboreal [illegible] and crannies, so many were the [illegible], [illegible] the great orchid-covered limbs and [illegible] and so loath to leave the darkness of the jungle. The orchids and epiphytic [illegible] and became so heavy a burden at times as to [illegible] down the limb or even the entire tree [illegible] them, and not infrequently I witnessed the downfall of some tree overburdened in this manner [illegible] warned by a premonitory crackling, I was [illegible] move with considerable speed to escape a [illegible].

Mosquitoes, the former bane of early Canal [illegible], were found but sparingly. Even outside the [illegible] government patrol we were bothered but little by them, although we were told that later, during the rainy season, they were much worse. A few spots were encountered where mosquitoes were bothersome, [illegible] arguing a local distribution. The ticks and red bugs, however, made up in diligence for any slights we might feel we had suffered from not being met by mosquitoes. The jungle everywhere seemed to harbor these pests and they did all they could to make life miserable for us. Ants also were found in abundance and it was fortunate indeed that our camp was a floating one and thus cut off from inroads of these nuisances. One species of ant in particular will be long remembered by two members of the party, for it stung with a venomous vigor never equalled by any bee and made the victim imagine he had been struck by a snake at least.

Concentration of animal life had taken place at the rising of Gatún Lake, and most of the islands formed had many inhabitants at first. The Gatún Hunt Club, however, soon reduced the population of these islands by hunting them with hounds, and as the quarry in most instances could not leave the island, the result was a clean sweep of all the larger species. We were too late, consequently, to find abundant game on any of the islands near Gatún. I accompanied this hunt club on one occasion, securing two peccaries.

The most efficient method of hunting the Panamanian jungle was by means of a headlight at night. The rays of the light, worn on the hunter's head, are reflected by the eyes of the animal, which shine like two orbs of fire—red, green, or bluish, depending on the animal "shone." The hunted animal will see nothing but the approaching light and falls an easy victim to the rifle or shotgun. On account of the danger to domestic stock and to people by promiscuous shooting at night, this method has been prohibited on the Zone, but beyond Zone limits it is to-day the favorite mode.

The trip resulted in a good series of flashlight photographs of opossums and some of the smaller mammals. The apparatus for "flashing" the animals was set out by some runway or water-course where animals were apt to pass, and consisted of a mechanism to fire a magnesium flash and at the same time trip the shutter of the camera, which was fastened in a manner to command the trail. A thread attached to a bait and stretched out before the camera fired the flash when the animal pulled it.

Series of the rodents and the smaller mammals were secured for the Museum collections and for the most part are of species not hitherto represented. The time was too limited to secure many of the larger mammals which are found in the Zone.

* The expedition worked under authority from the Canal Commission. It is of note that Colonel Goethals, as the first civil governor of the Canal Zone, continues adherence to the policy he maintained during the engineering work in the region, namely, that the Isthmus shall be a game preserve. Exception to the observance of the laws against shooting game outside a short open season will be made only in favor of such occasional zoological expeditions. Reprinted by permission from the *American Museum Journal*. Illustrations by courtesy of Mr. George Shiras, 3rd, who organized the expedition and made the flashlight photographs; and also of the author, who photographed the general scenes.

Electric Power for Agriculture

The idea of applying electric power to agricultural operations is attracting attention, especially in view of the great hydro-electric plants that are being developed in districts remote from present manufacturing [illegible] ties, where the power must be [illegible] distances. If some of this power could be utilized [illegible] it would be a good thing for both the producer of electricity and the user, as it would [illegible] [illegible] lead to [illegible] [illegible] this in turn would [illegible] the power to [illegible] lower rate, as more [illegible] increasing the overhead expenses. One [illegible] cation of electricity in some [illegible] running irrigating pumps, and this [illegible] nomically if enough power was taken to [illegible] installation of the [illegible]. There [illegible] ery on every [illegible] which would [illegible] cost was [illegible], and the [illegible] ing plants would [illegible] power for [illegible] [illegible]

Protection Against Torpedoes*

A Discussion of the New Conditions Created by Mines and Submarines

Although the cause of the sinking of the "Formidable" in the Channel on New Year's Day is not known to the public with any certainty, it is generally assumed that either a torpedo or a mine was responsible. If a torpedo was really the cause, then the highest praise is due to the German submarine which fired it. The weather was extremely rough at the time and the difficulties to be encountered were enormous; so great, indeed, that we are almost prepared to regard them as insuperable. If, on the other hand, we accept the alternative, we are faced with the problem how a German mine got so far west. We say a "German mine," because there is some reason for believing that the Germans are not careful to ensure that their fixed mines go automatically out of action, as ours do, when they break adrift from their moorings, and they alone use the barbarous free floating un-timed mine. Probably the Admiralty is in a position to say which of these two causes, both of which have elements of improbability, was really responsible, and we are not likely to know for a long time to come. In the meanwhile the problem of the resistance of ships to submarine attack has been raised by this latest loss.

The subject is one that has attracted a great deal of attention in recent years; but, on account of the new policy pursued by the Admiralties of most countries and of our own particularly, very little is known outside a limited circle, as to what steps have been taken to guard against this ever-increasing danger. As we shall show presently, it is probable that no country fully appreciated the submarine menace when the war began. Until a few years ago there was never any question of armoring ships' bottoms. It was thought that a moving ship could generally maneuver out of the way of a torpedo when it was conscious of the direction from which it came, as, for example, in the case of an attack from a destroyer. Protection then was only needed when the vessel was at rest, and for this purpose the torpedo net was given to all ships of any size. The net, however, is no longer an infallible defence against modern torpedoes, and since the development of the submarine, with its invisible attack, the stationary or slow moving ship is at a great disadvantage. A new method of defence is needed. The problem is one of extreme difficulty. There are only two lines on which a solution is to be sought if complete immunity is to be found. Either the bottom plating of the vessel must be made so powerful that the explosion of a torpedo against it can cause little damage, or means must be discovered for keeping the torpedo at a distance. In harbor it is not very difficult to ensure the latter. Obstacles may be placed to guard the entrance and, as a secondary precaution, the nets may be lowered on the ships themselves. In the open sea such protection is impossible, and the only course is to depend upon speed, manoeuvering qualities, and gun fire. By these means the submarine may be driven off or avoided, and it is also conceivable that in certain states of the sea, when its approach is made visible by its wake, the torpedo might be sunk or exploded by gun fire with suitable projectiles. Generally speaking, however, recourse to such means is out of the question, and safety lies only in the discovery and destruction or avoidance of the attacking vessel. Where the latter is a submarine and the water is broken the difficulty is great, and the best defence remains irregular speed on an irregular course. We are thus left with the fact that no mechanical means have yet been discovered to prevent a well-aimed torpedo striking its mark with, in the case of older ships at least, fatal effect. The only hope, then, lies in so constructiong the bottoms of ships that the submarine explosion shall do no or only localized injury. It is on this line that architects are working.

Whether or not the bottoms of our latest ships are armored we cannot say; but even if they are not. which is probably the case, a form of subdivision similar to that employed in recent French ships—the "Bretagne" class for example—is used. In general terms this consists in forming a long internal caisson or cofferdam inside the vessel at the vulnerable under-water parts. It forms in fact a kind of double skinning, only that the space between the outer and inner skin is greater than in passenger vessels and the inner skin is made thick and of a particularly tough kind of steel. Occasionally a flexible diaphragm is placed midway between the two skins, and helps to protect the inner one against injury. The force of the explosion of a mine or torpedo expends itself in destroying the outer skin and is unable to damage seriously the inner. The ship is, of course, badly injured, but not sunk. We know that this plan has been adopted in British vessels, for Mr. T. G. Owens has stated that "in most of the later ships there are submerged longitudinal protective bulkheads to ward against the effect of submarine explosions, either from torpedoes of mines" (Inst. N.A.), and we have good grounds for hoping that any of the latest battleships and battle-cruisers would not suffer the fate of the old vessels that have been sent to the bottom by the invisible attacks of the enemy; but we may ask how long after such an explosion would the damaged vessels again be available for service. "Sub-division," said Sir John Biles at Newcastle last July, "naturally suggests itself as one means of minimizing the effect of this damage; but, when all that is possible in this direction has been done, there seems to be no great certainty that a battleship will still be a formidable fighting machine after having received the successful contact explosion of a 21-inch torpedo." He then asked, "Can we do anything in addition to sub-division to preserve the ship for effective fighting purposes?" and replied, "The effective advent of the submarine seems to justify a serious consideration of the question of applying armor to the bottoms of ships." Sir John then showed that if the bottom was to be armored with 4-inch plates, which he suggested would be needed, a reduction in speed of two knots or a diminution of above-water armor would be necessary.

Speaking on this paper, Sir Philip Watts made one or two remarks that give us some insight into the course adopted by the Admiralty. He said: "Defence can be provided by fitting deep inner bottom spaces backed with tough protective plating, by which the loss of buoyancy resulting from a hit may be considerably restricted," and "Up to the present time the submarine menace has not been considered of sufficient importance to justify the adoption of armor for protecting the bottom; although discussed from time to time it has never been fitted." Sir Philip Watts and many others may now see reason to alter their views, but it must be remembered that with a single possible exception, about which little or nothing is known save from American sources, no modern big British ship has suffered from mines or torpedoes. Only elderly ships have been sunk, ships that were built when submarines were little considered. On the other hand, it appears that the "Viribus Unitis" was torpedoed recently by the French, and it is reported that a modern French ship of the "Courbet" type (1910) has also been struck, but in neither case has the vessel sunk. There is a rumor also that the "Goeben" has just been torpedoed without sinking. The reason in these three instances may be that in not one did the torpedo reach a fatal spot, but equally it may be that the new form of construction does, at least, save the life of the ship.

It will be gathered from this brief review of the position that while armored bottoms have been discussed, they have not been adopted, but that practically all recent ships are provided with under-water chambers or caissons, on which the explosion of mines or torpedoes can expend themselves, and are in other ways subdivided. The only other protection against submarine attack is the mobility of the vessel herself and the use of nets. Sub-division does not protect a vessel from injury of such a nature that she would have to spend many weeks in dock after a successful attack, and hence it cannot be regarded as final. We are thus driven to the conclusion either that armoring of bottoms must become a general practice or that some entirely new means of repelling or nullifying attack must be found. Here is a problem upon which our readers might exercise their ingenuity. It is, we admit, not very promising, but we suggest as a course which does hold out some hope of success that in the first place means for discovering the position of an unseen submarine might be sought. To know the position of your enemy is to win half the battle, and if we could discover some device which would lend sub-marine eyes to the battleship as the aeroplane has lent super-terranean sight to the general staff, we should be on a long way to avoiding such calamities as have occurred. It is well known that all submarines are noisy and that in a submerged condition they are driven by powerful electrical machinery. We suggest that two lines of research are opened by these facts. A modification of the submarine bell apparatus now fitted to many merchant ships might be used to discover the direction in which a submarine lay, or some delicate device which would discover its position by magnetic means might be invented. The matter, of course, bristles with difficulties, which are increased by the fact that the information on which invention must be based cannot be obtained; yet the more minds are directed to the problem the nearer shall we be to a solution.

* The Engineer.

On the Temperature of the Mercury Arc*

By J. C. McLennan, University of Toronto

In the course of some experiments recently carried out by the writer on the fluorescence of iodine vapor under stimulation by the light from the mercury arc, it became necessary to know the temperature to which the iodine vapor was submitted during the exposures. As there appeared to be no information available on the temperatures obtainable from such types of mercury arcs as those used in the fluorescence experiments mentioned, a few sets of observations were made and an account of these is given in the following note.

[illegible] who had studied the temperatures in electrical discharges in hydrogen, nitrogen, and atmospheric air at low pressures in Geissler tubes provided with Wehnelt [illegible] has shown that with currents of about an ampere passing in the tubes temperatures beyond 1,000 deg. Cent. have been observed with thermocouples [illegible]

[illegible] found to characterize the discharge in the mercury arc when a thermocouple was exposed directly to the luminous vapor.

[illegible] Royal Society of Canada, and [illegible]

To bring out this point measurements were made on the discharge in a tube that had a platinum-iridium thermo-couple sealed into it with one junction situated at the axis of the tube. The terminals were joined —one to a standard Siemens and Halske potentiometer, and the other cooled to 0 deg. Cent, by melting ice— and this gave the electromotive forces of the junction when discharges of different intensities were sent through the tube.

In making the observations the tube was joined to the 110-volt direct current supply circuit with a variable resistance in series which enabled one at will to modify the strength of the current in the arc.

Before sealing the wires into the tube the thermo-couple was calibrated by exposing the junction to a series of temperatures given by (1) melting ice, (2) water and naphthalene boiling at atmospheric pressure and (3) zinc, coin silver, and potassium sulphate at their respective melting points.

In making observations the fall of potential between the two terminals of the tube was measured simultaneously with the strength of the current passing through it. At the same time the corresponding electromotive forces were read off from the compensation apparatus.

A temperature of 1,400 deg. Cent. was reached when a current of 10.6 amperes was passing through the tube and it was deduced by supposing that the calibration curve was rectilinear beyond 1,070 deg. Cent., the highest point of calibration. Platinum, platinum-iridium thermo-couples are not generally used in measuring temperatures higher than 1,100 deg. Cent., or at most 1,200 deg. Cent., but in the present case it was found that the couple still remained intact when an electromotive force of 106 x 10^{-4} volts was reached and this was taken from the curve as representing approximately 1,400 deg. Cent.

It is quite clear that with a platinum platinum-rhodium thermo-couple still higher temperatures might have been recorded, but after the maximum current of 10.6 amperes had been running for a short time the tube cracked and the investigation was not carried further.

The investigation shows that with a moderate consumption of energy the luminous vapor in the mercury arc may attain and easily exceed a temperature of 1,400 deg. Cent.

The investigation suggests, too, that in all probability the temperatures indicated by a thermo-couple when exposed directly to the discharge are still very much below that corresponding to the mean molecular kinetic energy of the luminous vapor. The most satisfactory way, though a difficult one, to ascertain the temperature, would be to investigate the form and variation in width of a selected spectral line when the consumption of energy in the arc is varied.

Edward Weston's Inventions

Revolutionizing Discoveries that Resulted from Exact Observation and Original Chemical Theories

By Dr L H Baekeland

The pioneer work of Dr Edward Weston is not easy to describe in a few words His restless inventive activity has been spread over so many subjects has intertwined so many interlocking problems that in order to understand its full value it would be necessary to enter into the intimate study of the various obstacles which opposed themselves to the development of several leading industries which he helped to create the electrodeposition of metals the electrolytic refining of copper the construction of electric generators and motors the development of electric illumination by arc- and by incandescent-light and the manufacture of electrical measuring instruments An impressive list of subjects but in every one of these branches of industry Weston was a leader and it was only after he had shown the way in an unmistakable manner that the art was able to make further progress and develop to its present day magnitude

But why was Weston able to overcome difficulties which seemed almost unsurmountable to his predecessors and co-workers in the art?

The answer is simple He introduced in most of his physical problems a chemical point of view—a chemical point of view of his own a point of view which was not satisfied with general statements but which went to the bottom of things He did not get his chemistry wholesale as it is dispensed in some of our hot-bed method educational institutions He had to get at his facts piecemeal one by one adjust them ponder over them—collect his facts with much effort and discrimination he did not acquire his knowledge merely to pass examinations but to use it for accumulating further knowledge

It seems rather fortunate for him that one of the first employments he got in New York was with a chemical concern which made photographic chemicals This was the time of the wet-plate when photographers made their own collodion their own silver bath their own paper Whoever went through those delicate operations knew the difficulties the uncertainties which were caused by small variations in the composition of chemicals or in the way of using them Photochemistry is excellent experience for any young chemist who is disposed to generalize too much all chemical reactions by mere chemical equations Whoever has to deal with those delicate chemical phenomena which occur in the photographic image knows that many unforeseen facts can not easily be accounted for by our self satisfying but often superficial generalizations of the text-books

Weston's tendency to observe small details in chemical or physical phenomena led him to improve the art of nickel plating and electrolytic deposition of metals to a point where it entered a new era When he undertook the study of the difficulties in this art he took nothing for granted but by close observation he succeeded in devising methods not only of improving the physical texture of the deposit but for increasing enormously the speed and regularity with which the operations could be carried out all these improvements are now embodied in the art of electrotyping nickel gold and silver plating

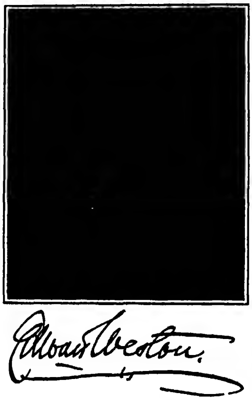
At this time attempts had already been made for the commercial refining of copper by means of the electric current But this subject was then in its first clumsy period far removed from the importance it has attained now among modern American industries Here again Weston brought order and method where chaos reigned His careful laboratory observations harnessed by his keen reasoning intellect established the true principles on which economic industrial electrolytic copper refining could be carried out Prof James Douglass (Commencement address Colorado School of Mines *Metallurgical and Chemical Engineering* Vol XI No 7 July 1913 page 377) referred to this fact in a recent address

I suppose I may claim the merit of making in this country the first electrolytic copper by the ton but the merit is really due him (Weston) who in this and innumerable other instances has concealed his interested work for his favorite science and pursuits under a thick veil of modesty and generosity

The whole problem of electrolytic refining when Weston took it up was hampered by many wrong conceptions One of them was that a given horse-power could only deposit a maximum weight of copper regardless of cathode- or anode-surface This fallacious opinion was considered almost an axiom until Weston showed clearly the way of increasing the amount of copper deposited per electrical horse-power, by increasing the number and size of vats and their electrodes, connecting his vats in a combination of series and multiple, the only limit to this arrangement being the added interest of capital and depreciation on the increased cost of more vats and anodes in relation to the cost of horse-power for driving the dynamos.

The electro-deposition of metals forced Weston into the study of the construction of dynamos Until then the electric current used for nickel- silver- and gold-plating as well as for electrotyping, was obtained from chemical batteries Weston says that it was almost a hopeless task to wean electroplaters from these cells to which they had become tied by long experience and on the more or less skilful use of which they based many of the secrets of their trade

If the dynamo as a cheap and reliable source of electric current was advantageous for nickel-plating, it became an absolutely indispensable factor for electrolytic copper refining At that time the dynamo was still at its



very beginning—some sort of an electrical curiosity It had been invented many years before by a Norwegian Soren Hjorth who filed his first British patent as far back as 1855 Similar machines had been built both in Europe and America, but little or no improvement was made until Weston in his own thorough way undertook the careful study of the various factors relating to dynamo efficiency

In 1876 Weston filed his first United States patent on rational dynamo construction which was soon followed by many others and before long he had inaugurated such profound ameliorations in the design of dynamos that he increased their efficiency in the most astonishing manner Heretofore the dynamos which had been constructed showed an efficiency not reaching over 15 to 40 per cent gross electrical efficiency but the new dynamos constructed after Weston's principles increased this to the unexpected efficiency of 95 per cent and a commercial efficiency of 85 to 90 per cent He thus marked an epoch in physical science by constructing the first industrial machine which was able to change one form of energy motion into another electricity with a hitherto unparalleled small loss As the improvements in dynamos depend almost exclusively on physical considerations, and have little relation with the field of chemistry I shall dispense with going further into this matter But I should be permitted to point out that the first practical application of electrical power transmission for factory purposes in this country, was first utilized in Weston's factory, the success of this installation induced the Clark Thread Works also located in Newark, N J, to adopt this method of power transmission for some special work, a method which now has become so universal For this purpose, Weston had to invent new devices for starting, and for controlling, as well as for preventing injuries to motors by overload.

In Weston's factory also the electric arc was used for the first time in the United States for general illumination

In fact from 1875 to 1886, Weston was very energetically engaged with the development of both systems of arc- and incandescent-illumination by electricity. We see him start the manufacture of arc-light-carbons according to methods invented by him, and thus he became the founder of another new industry in America. He continued this branch of manufacture until 1884, at which epoch this part of the business was transferred to another company which has made a specialty of this class of products and has developed it into a very important industry Here again Weston introduced chemical methods and chemical points of view Among the many objections which the public had against the electrical arc was the bluish color of its light Women especially complained that the blue-violet light did not bring out their complexion to the best advantage Weston first tried to use shorter arcs which gave a whiter light but this was only a partial remedy He soon found a more radical and more complete cure by the introduction of vapors of metals or metallic salts or oxide in the arc itself so as to modify at will the color of the light and thus he became the inventor of the so-called flaming arc. It is noteworthy that it took about 20 years before electricians and illuminating engineers became so convinced of the advantages of the flaming arc, that it had to be "re-invented" during these late years, and now it is considered the most efficient system of arc-illumination

In relation to this invention it is interesting to quote the following extract of the specifications from his United States Patent No 210 380 filed November 4th, 1878

This rod or stick may be made of various materials—as for example of so-called "lime glass" or of compounds of infusible earths and metallic salts, silicates double silicates mixtures of the silicates with other salts of metals fluorides double fluorides mixtures of the double fluorides fusible oxides or combinations of the fusible oxides with the silicates—the requirements, so far as the material is concerned being that it shall be capable of volatilization when placed on the outer side of the electrode to which it is attached and that its vapor shall be of greater conductivity than the vapor or particles of carbon disengaged from the carbon electrodes The foreign material added to the carbon may be incorporated into the electrode by being mixed with the carbon of which the electrode is composed or it may be introduced into a tubular carbon but I have found it best to place it in a groove formed longitudinally in the side of the electrode as shown

In his endeavor to make the electric incandescent lamp an economic possibility we see him introduce over and over again chemical methods and chemical considerations He first tried to utilize platinum and iridium and their alloys which he fused in a specially constructed electric furnace, devised by him antedating the furnace described by Siemens This is probably the first electrical furnace, if you will except the furnace which Hare used in his laboratory in Philadelphia

But these platinum metals showed serious defects aside from their high cost and by that time Weston had become so familiar with the properties of good carbon that like other inventors, he became convinced that the ultimate success lay in that direction

And now we see him join in that race of rivalry among inventors who all engaged their efforts in search of the real practical incandescent lamp Among this group of men the names of Edison here in the United States and that of Swan in England, have been best known. To go into the details of this struggle for improvement is entirely outside of the scope of this short review

Edison succeeded in making incandescent lamp filaments by carbonizing selected strips of bamboo. But even a carbon made of this unusually compact and uniform material was far from being sufficiently regular and homogeneous. Indeed all the then known forms of carbon conductors had the fatal defect of a structural lack of homogeneity On account of this, the resistance varied at certain sections of the filament, and at these very spots, the temperature rose to such an extent that it caused rapid destruction of the filament; this is somewhat similar to the chain which is just as strong as its weakest link

These irregularities in the filament reduced enormously the term of service of any incandescent lamp. Weston tried to solve this difficulty by means of his chemical knowledge. He [illegible]

when he went to visit the gas works to obtain some hard carbon for his Bunsen cell, this carbon was collected from those parts of the gas retort which had been the hottest, and where the hydro-carbon gas had undergone dissociation leaving a dense deposit of coherent carbon.

In this chemical phenomenon of dissociation at high temperatures he perceived a chemical means for 'self-curing" any weak spots in the filament of his lamp The remedy was as ingenious as simple. In preparing his filament, he passed the current through it while the filament was placed in an atmosphere of hydrocarbon gas, so that in every spot where the temperature rose highest on account of greater resistance brought about by the irregular structure of the material, the hydro-carbon gas was dissociated and carbon was deposited automatically until the defect was cured with the result that the filament acquired the same electric resistance over its whole length But this invention however brilliant, did not limit his efforts He had become imbued with the idea that the ideal filament would be an absolutely structureless, homogeneous filament with exactly the same composition and the same section throughout its whole length He reasoned that such a filament could not be obtained from any natural products ducts neither from paper nor bamboo but that it had to be produced artificially in the laboratory from an absolutely uniform structureless chemical substance After various unsuccessful attempts he finally secured this result by applying his old knowledge of the days when he used to make collodion He produced a homogeneous, structureless transparent film of nitrocellulose by evaporating a solution of this material in suitable solvents As he could not carbonize this film on account of the well-known explosive properties of so-called gun cotton he obviated this difficulty by eliminating the nitrate group of the molecule of cellulose-nitrate by means of ammonium-sulphydrate This gave him a flexible transparent sheet very similar in appearance to gelatine this material he called 'Tamidine Such films could be cut automatically with utmost exactitude producing filaments of uniform section which then could be submitted to carbonization before fastening them to the inside of the glass bulb of the incandescent lamp

It is interesting to note here that the modern Tungsten lamp, in all its perfection made of ductile tungsten is after all, the fullest development of the principle of an entirely structureless homogeneous chemical filament The tungsten-filament can stand much higher temperatures than carbon and this property gives it higher lighting efficiency but the former tungsten filaments of a few years ago which had a granular structure had the same defect as the earlier carbon lamps, namely a non homogeneous texture and correspondent short life

While Weston was wrestling with all his electrical problems, and more particularly with the construction of dynamos and motors he was handicapped continuously by the clumsy and time-consuming method of electrical measurements which were the best existing at that period Up till then, these methods had been found good enough for physical laboratories, where the lack of accuracy did not result disastrously in hitting the pocket of the manufacturer or where time—abundant time for observations and calculations was always available But progress in the electrical industries lagged behind the delay and uncertainties caused by electrical measurements So Weston was compelled to invent for his own use a set of practical electrical measuring instruments It was not long before some of his friends wanted very badly duplicates of his instruments, before he knew it, he was giving considerable attention to the construction and further development of these instruments Just about this time, the electric light and dynamo construction enterprise entered into a new period where they began to develop in large unwieldy commercial organizations requiring public franchises and which had to be backed by vast amounts of new capital. In its boards of directors business men, or financial men and corporation lawyers became paramount factors and eclipsed in importance the technical or scientific men, who, in earlier days, had almost exclusively contributed to the development of the art.

Following his natural inclinations Weston soon abandoned his former business connections in order to entrench himself in a field where individuality, science and technology were of almost unique importance, and which he could develop without the necessity of incurring financial obligations beyond what he could master personally. Thus he dropped his connections with the electric light and dynamo enterprises, and we see him now, heart and soul, in another new industry which he created—the art of making accurate, trustworthy and [illegible] electrical measuring instruments.

In his factory in Newark, N. J., Weston seems to have instilled some of his own reliability and accuracy in the minds of the men and women he employs.

[illegible]

trustworthy measuring instruments nor create reliable measuring methods?

What Stas did in chemistry for atomic weights Weston did for electrical measuring he created radically new methods of measurement and introduced an accuracy undreamt of heretofore Do not forget that his problems were not easy ones When the British government offered a prize of $100 000 for the nearest perfect chronometer the problem of a reliable chronometer involved considerably less difficulties and fewer disturbing factors than any of those encountered in devising and making electrical measuring instruments But here again, even at the risk of monotonous repeating I want to impress you with the fact that the success of the methods of Weston was found in almost every case in the application of chemical means by which he tried to solve his difficulties

When he took up this subject the scientists as far back as 1884 accepted implicitly the belief that the definition of a metal and a non-metal residue lay in a physical distinction that for metals the electrical resistance increased with temperature, while for non metals their resistance decreased with temperature This was another one of those readily accepted axioms which nobody dared to refute or contest because they were repeated in respectable text-books And yet this unfortunate behavior of metals was the greatest drawback in the construction of accurate measuring instruments Indeed on account of the so-called temperature co-efficient all measurements had to be corrected by calculation to the temperature at which the observation was made This seems easy enough but it was time consuming and often it is more difficult to make rapid accurate observations of the temperature of the instrument itself First of all, the thermometers are not accurate and have to be corrected periodically and furthermore it is not an easy matter to determine rapidly the temperature of a coil or an instrument Moreover by the very passage of the electric current fluctuating changes in temperature are liable to occur which would make the observations totally incorrect All this led to hesitation and slowness in measurements Weston wanted to correct this defect but he was told that the very laws of physics were against his attempts Before he was through with his work he had to correct some of our conceptions of the laws of physics now let us see how he did it

Weston knew that the favorite metal for resistances was so-called German-silver Strange to say he was the first one to point out to the Germans themselves that German-silver is a word which covers a multitude of sins and that the composition of German-silver varies considerably according to its source of supply The result was that he soon proposed a standard copper and nickel- and zinc-alloy containing about 30 per cent of nickel and which had a resistance of almost twice that of ordinary German-silver and a much lower temperature co-efficient Not satisfied with this he took up the systematic study of a large number of alloys The first batch which he undertook to study amounted to more than 300 different alloys Since that time he has considerably increased this number and is still busy at it Everyone of these alloys he made himself in his laboratory starting from pure materials and controlling the whole operation from the making of the alloy to the drawing of wires of determined size By long and repeated observations on which many years have been consumed he was able to determine the electrical behavior of each one of these alloys at different temperatures After awhile he began to observe remarkable properties in some manganese alloys he compounded He managed to produce an alloy which had 65 times the resistance of copper But getting bolder and bolder he strove to obtain an alloy which had no temperature co-efficient whatever He not only succeeded in doing this but finally produced several alloys which had a *negative* temperature co-efficient In other terms their resistance instead of increasing with rise of temperature, decreased with increasing temperature He also showed that the resistance of these alloys depended not only on their composition, but on certain treatments which they undergo for instance preliminary heating And since that day the physicists have had to bury their favorite definition of metals and non metals The present generation can hardly realise what this discovery meant at that time I could not better illustrate this than by reminding you of the fact that in 1892 at the meeting of the British Association for the Advancement of Science where it was urged to found an institution similar to the Deutsche Reichsanstalt Lord Kelvin said in his speech

"The grand success of the Physikalische-Reichsanstalt may be judged to some extent here by the record put before us by Prof von Helmholtz Such a proved success may be followed by a country like England with very great profit indeed One thing Prof von Helmholtz did not mention was the discovery by the Anstalt of a metal whose temperature co-efficient with respect to electrical resistance is practically nil; that is to say a metal whose electrical resistance does not change with temperature This is just the thing we have been waiting for for 20 or 30 years It is of the greatest importance in scientific experiments and also in connection with the measuring instruments of practical electric lighting to have a metal whose electrical resistance does not vary with temperature and after what has been done what is now wanted is to find a metal of good quality and substance whose resistance shall diminish as temperature is increased We want something to produce the opposite effect to that with which we are familiar The resistance of carbon diminishes as temperature increases but its behavior is not very constant Until within the last year or so nothing definite was known of metals from the fact that elevation of temperature had the effect of increasing resistance The Physikalische Anstalt had not been in existence two years before this valuable metal was discovered

Then followed this colloquy

Prof Von Helmholtz The discovery of a metal whose resistance diminished with temperature was made by an American engineer

Prof Ayrton By an Englishman—Weston

Lord Kelvin That serves but to intensify the position I wished to take whether the discovery was made by an Anglo-American an American Englishman or an Englishman in America It is not gratifying to national pride to know that these discoveries were not made in this country

The misinformation of Kelvin was due to the fact that after the Weston patents had been published his alloy was called *manganin* in Germany and much publicity had been given to its properties with scant reference to its real inventor an occurrence which unfortunately is not infrequent not only among commercial interests but in technical or scientific circles as well

No less important was the invention of the Weston cell which in 1908 by the international commission for the establishment of standards of electrical measurements has become the accepted universal practical standard for electro-motive force Here again this physical standard was obtained by chemical means

Until Weston's researches on standard cells the Clark cell had been the standby of the electricians and electro-chemists of the world as the standard of electro motive force It required the keen analysis of a Weston to ascertain all the defects of this cell and to indicate the cause of them Later he drew from his careful chemical observations the means to construct a cell which was free from the defects of its predecessors a cell that had no temperature co-efficient and had no lag

He detected that the choice of a saturated solution of sulphate of zinc in which was suspended an excess of crystals of this salt was an unsuitable electrolyte and one of the principal causes why the indications of the Clark cell varied considerably with the temperature It is true that this could be obviated by placing the cell in a bath of constant temperature But this involves new difficulties due to the proper determination of the real temperature Furthermore there is always a lag in the indications due to the fact that at varying temperatures it requires a certain time before the solution of the salt has adjusted itself to the co-efficient of saturation for each newly acquired temperature By studying the comparative behavior of various salts at different temperatures he came to the conclusion that cadmium sulphate is more appropriate and this was one of the several important improvements he introduced in the construction of a new standard of electro motive force

Dr Weston assures me that he has succeeded in making his alloys to show only a change of one-millionth for a variation of 1 deg Cent The metallic alloys he discovered are used practically in nearly all kinds of electrical measuring instruments throughout the world Weston instruments and Weston methods are now found in all properly equipped laboratories and electro-chemical establishments of the world On a recent trip to Japan I saw them in the University of Tokio as well as in the Japanese war museum where their battered remains attested that the Russians used them on their captured battleships I have worked in several laboratories in Europe equipped with instruments said to be just as good as those of Weston but in most instances they were imitations of Weston instruments and it was significant that they kept at least one Weston instrument to be used to correct and compare their national product

Long Reinforced Concrete Bridges

REINFORCED concrete is so rapidly coming into general use that some figures relating to bridges of considerable size of this construction are of unusual interest According to recent statements the Walnut Lane Bridge, at Philadelphia, has a span of 233 feet, at Grafton New Zealand there is a bridge with a span of 320 feet over the Tiber, at Rome 328 feet, at Langwies, Switzerland, 330 feet, and the proposed bridge over Spuyten Duyvil Creek, New York, 703 feet.

The Gas from Blast Furnaces—II*

Its Cleaning and Utilization

By J E Johnson, Jr

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No 2040, Page 95, February 6, 1915

With this introduction I cannot do better than quote extensively from Mr Forbes's paper as follows

DUST CONTENT IN GAS

The gas leaving the usual dust-catcher contains an average of from 3 to 4 grains of dust per cubic foot and its further cleaning is accomplished in one or two principal stages depending on the ultimate use of the gas namely primary cleaning and final cleaning In primary cleaning the gas is sufficiently cleaned for economical use in heating hot blast stoves and for raising steam in boilers it has been found that the best results are obtained when the dust content of the gas after cleaning does not exceed 0 2 grain per cubic foot In final cleaning the gas is sufficiently cleaned for use in gas engines and in this case the best practice has resulted when the dust content of the gas after cleaning does not exceed 0 008 grain per cubic foot

Various systems and methods are employed for accomplishing the desired results In modern practice the gas leaving the blast furnace is in practically all cases conducted through down-comer mains and then through a dust-catcher of large capacity and in some cases through two such dust-catchers in series A considerable proportion of the heavier dust is deposited at this stage From the dust-catcher the gas passes to the additional cleaning apparatus through gas mains usually equipped with downtakes and valves for the removal of the deposited dust The mode of treatment from this point on varies considerably according to the opinions of the operators as to the respective merits of various systems

PRIMARY DRY CLEANING

For primary cleaning a separation of the dust without the use of water in other words dry cleaning has been in favor at many plants on account of the ability to thus conserve the sensible heat of the gas which is lost when water is used The fact however should not be lost sight of that the benefit derived from the sensible heat of the dry-cleaned gas is largely discounted by the amount of water vapor in the gas This is especially the case with gas from blast furnaces operating with a high top temperature and using ores and coke containing much moisture existing either free or chemically combined the water vapor affects the efficiency of the combustion of the gas

An additional benefit of dry cleaning lies in the greater facility to handle and handle the flue dust in the dry state than in the form of mud or slime in the wet cleaning processes As before stated the basic principles in practically all of these dry-cleaning systems depends upon a change in the direction of the gas a reduction in its velocity and the separation of the dust by gravity and centrifugal force The various modifications by which this separation of dust is accomplished are all evolved from the so-called cyclone processes developed in Germany about 20 years ago Some of these systems recently developed in the United States are the Brassert-Witting the Roberts, the Kennedy and the Dyblie A description of the Brassert-Witting whirler and of the Dyblie whirler will illustrate the general principles of this type of cleaner

BRASSERT-WITTING WHIRLER

As shown in Figs 5 and 6, the Brassert-Witting whirler consists of a vertical outer cylindrical casing A and an inner inverted tube B which at its upper ends is intergral with the gas main C which takes the cleaned gas away from the apparatus This inverted tube is flared at its lower end D a number of iron or steel bars E are fastened vertically around the chamber F and extend from a point well above the lower edge of the flared end D of the pipe to a point well below the lower edge of this pipe In the lower part of the chamber F is placed a cone G which allows the separated dust to enter the outlet pipe

The gas enters the apparatus tangentially through the flue H and is given a rotary whirling motion through the annular space between the pipe B and the wall of the chamber A On coming in contact with the bars E the dust is caught in the channels between these bars and is held in position by the combined action of centrifugal force and friction As the gas continues to rotate within the annular spaces above mentioned its velocity is gradually increased by the action of the flared end of the receiving pipe until when it reaches the lower edge of the end its velocity is at a maximum On passing below this edge the velocity is constantly decreased the direction of the gas is changed and it passes upwardly through the flared end of the pipe to the outgoing gas main C

The dust which has been caught in the channels between the baffle bars drops vertically into the bottom of the chamber past the cone G and into the outlet pipe, whence it is removed as desired

BRASSERT MODIFICATIONS OF BRASSERT-WITTING WHIRLER

In the Brassert modifications of the Brassert-Witting whirler a sketch of which is shown in Fig 7, the lower portion of E of the casing is larger in diameter than the upper portion B and is provided with a series of inwardly projecting baffle plates F The lower portion G of the casing E is cone-shaped and constitutes the dust-receiving chamber In the bottom of this chamber is a cone H whose function is to direct the dust toward the periphery of the dust outlet pipe Within the chamber I another cone J is located and this cone is provided with a series of baffles, which are arranged as shown in Fig 8.

In Fig 9 which is a further modification, a spiral L is provided for the purpose of directing the flow of the gas The lower end of the outlet pipe is made barrel-shaped The outer casing M in its lower portion N is supplied with the baffles O which, instead of being mounted on the casing are bent inwardly therefrom, thus forming the apertures P (Fig 10) The section N of the casing is inclosed by an outer casing, Q, thus forming the annular chamber R, in which partitions S are placed to prevent whirling of the gas.

The gas is introduced and discharged and the dust is separated in a similar manner to that mentioned in the description of the Brassert-Witting whirler.

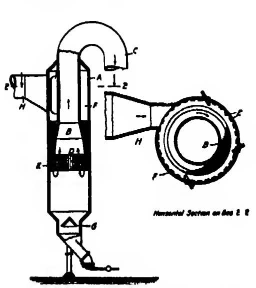
DYBLIE WHIRLER

In this whirler, as in most of these types, the separation is accomplished by combined centrifugal force and the action of gravity One of the principal features in this particular whirler is the arrangement in the spiral separator of the entrance and exit openings in substantially the same horizontal plane obviating the necessity of the gas changing its direction of flow at a sharp angle

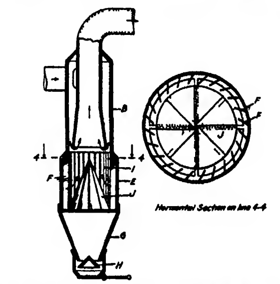
Described in general terms, this separator consists of a spiral conduit the lower open edges of which connect with the dust-collecting chamber The gas is introduced tangentially and follows a spiral course toward the central axis of the apparatus the spiral conduit being increased in area before the gas enters the central chamber prior to its exit from the apparatus

The dust is separated from the gas by centrifugal force and gravity, and falls through the lower open edges of the spiral into the dust-collecting chamber The central chamber is provided with a small opening at its lower end and connects with the innermost spiral of the spiral conduit

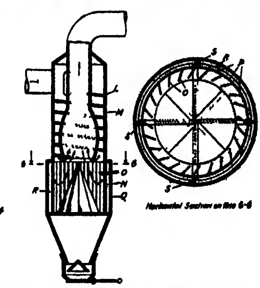
In the accompanying sketches, Fig 11 is a vertical section through the Dyblie whirler and Fig 12 is a horizontal section. The gas enters tangentially from the gas main through the opening A in the shell of the casing, the gas impinges upon the first turn of the



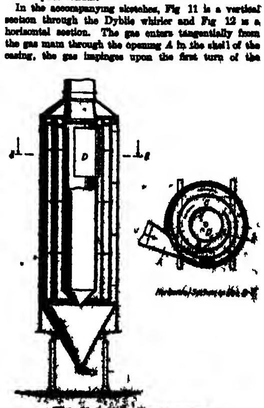
Figs. 5 and 6—Vertical and horizontal sections of Brassert Witting whirler



Figs 7 and 8—Vertical and horizontal sections of Brassert modification of Brassert Witting whirler



Figs. 9 and 10—Vertical and horizontal sections of Brassert modification of Brassert-Witting whirler.



Figs. 11 and 12

* Reproduced from Metallurgical and Chemical Engineering

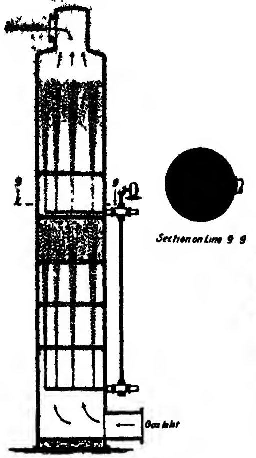


Fig. 13.—Duquesne spray tower

spiral B and follows the turns of the spiral A separation of dust from the gas occurs through centrifugal force, the particles of greatest specific gravity being thrown outwardly and falling by gravity to the bottom of the casing. At the point C an increased area is provided between the spiral and the central chamber which causes a decrease in the velocity of the gas thus allowing a further separation

The inlet A and the outlet D are in substantially the same horizontal plane and this permits the separated material to drop out of the whirling gas and prevents its being caught up in the vortex which happens when a sudden change in the direction of the flow of the gas occurs

A deflector E located at one edge of the opening is provided This is in the shape of a hook which acts to catch any dust which might be carried into the casing and this completes the separating operation

REMARKS ON EFFICIENCY OF DRY CLEANING

It has been demonstrated in practice that dry cleaning by anyone of the systems so far referred to cannot be depended upon by itself to continuously clean the gas from blast furnaces using much fine ore to the degree desired for use in stoves and under boilers the amount of dust remaining in the gas ranging from 1 to 3 grains per cubic foot depending on the working of the blast furnace. Such systems have a value however in removing by simple apparatus and at practically no operating expense a certain proportion of the dust, and so decreasing the duty upon any apparatus installed for further cleaning

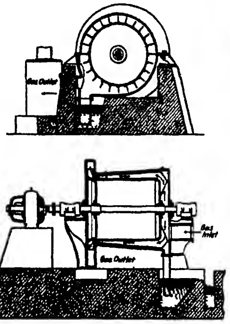
The above remarks on dry cleaning refer in no way to the Halberger-Beth system, recently developed in Germany, which will be treated separately later on

PRIMARY WET CLEANING

For primary cleaning, in Europe in particular a separation of the dust by the use of water has been preferred for many years to a dry separation, on account of the very much greater efficiency obtained in cleaning, and on account of the importance of reducing the water vapor contents of the gas to a minimum, thus allowing more efficient combustion. The cooling and washing of the gas are usually performed simultaneously [illegible] water being used to reduce the temperature of the [illegible] gases to practically the temperature of the incoming wash water. Experience has shown that cooling the gas in this manner, to allow condensation and separation of the water vapor, causes less [illegible] loss of heating efficiency than prevails in [illegible]

[illegible]

[illegible] almost entirely in [illegible]. These consist of [illegible] with a series [illegible] suitable intervals [illegible]



Figs. 16 and 17.—Theisen gas washer

which drip down between the grids and meet the gas coming up the gas being introduced at the bottom of the tower The intimate contact so obtained wets down the dust which is carried with the water to the bottom These Zschocke towers are usually water-sealed and cone-shaped at the bottom and the latest type has a siphon arrangement in either case the dust is readily removed from the bottom of the apparatus

Zschocke towers have been found sufficient to cool and clean the gas to the proper degree for use in hot-blast stoves under boilers and for similar purposes A fan washer into which water is introduced is frequently used as an auxiliary to the Zschocke towers for primary cleaning especially when the scrubbing capacity of the towers is small

A water separator equipped with internal baffles is usually located beyond the washer to allow separation of the entrained water

Zschocke washers are used considerably in the United States and some additional systems have also been developed here for the wet separation of dust for instance the Duquesne spray tower and the Steinbart spray tower The basic principle of these spray towers consists of the creation of a rain or spray by means of suitably arranged nozzles and the gas is cleaned and cooled in passing through this spray

DUQUESNE SPRAY TOWER

The Duquesne tower consists of a shell about 80 foot high by 12 feet in diameter As shown in Fig 13 the tower contains five sets of double screens the sets being spaced 6 feet 10 inches apart Under the first set of screens are distributed seven nozzles the feed water for which is controlled by a valve outside the tower Under the fifth set of screens seven similar nozzles also controlled by a valve outside the tower are distributed just above the range of the lower nozzles

The controlling valves have a revolving core which

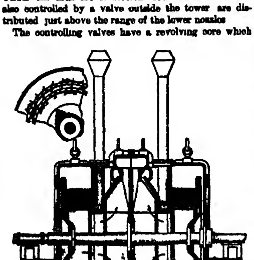
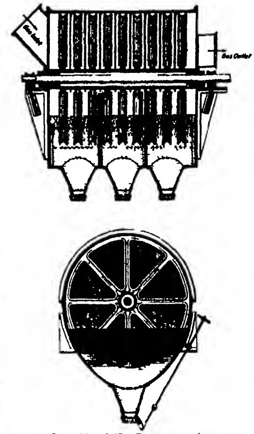


Fig. 18.—Theisen disintegrator



Figs 14 and 15.—Bian gas washer

successively blocks off the opening to the different nozzles thereby temporarily stopping the flow of water and creating an area of low pressure directly above the nozzle When the core has passed the flow of water resumes through this nozzle and sprays the gas which has reached this point The core is revolved electrically at the rate of about 15 revolutions per minute and a 5 horse-power motor is ample to operate four valves which are sufficient for two towers

The screens which are placed above the nozzles break up the water into fine drops permitting intimate contact of the gas and water

In the operation of these towers at Duquesne the gas rises through the scrubber at the rate of 4 feet per second and the water at the rate of 60 feet per second with a head of 35 pounds main pressure The gas is cooled down very effectively the temperature of the outgoing gas being only from 5 deg to 6 deg Fahr above the temperature of the incoming water while the moisture content averages only about 0 5 grain per cubic foot above the saturation point at the temperature of the outgoing gas

BIAN GAS WASHER

The Bian gas washer as shown in Figs 14 and 15 consists of a stationary horizontal steel cylinder through which the gas passes from one end to the other Inside the cylinder there slowly revolves a shaft which carries a number of vertical disks consisting of wire netting of fine mesh The diameter of these disks is very slightly less than the inside diameter of the cylinder and this arrangement necessitates the gas passing through the openings in the screens as it travels through the apparatus The screens to the extent of nearly half their diameter dip into the water contained in a trough upon which the open bottom of the cylinder rests and as the shaft revolves the part of the screens which has been immersed rises from the water with the meshes covered with thin films of water thus allowing thorough contact with the gas as it passes through the perforations

FINAL WET CLEANING

(Some of these systems can also be applied to primary cleaning)

The amount of cleaning accomplished in Zschocke and similar towers and in the Bian washer while satisfactory for stoves and boilers was found to be not sufficient when the gas was destined for use in gas engines and the systems of Theisen and Schiele were developed for this purpose

THEISEN GAS WASHER

The Theisen washer as shown in Figs 16 and 17 consists of a casing lined with a special wire netting within which revolves at high speed a drum carrying numerous fan blades set at oblique angles to the axis of rotation these blades or vanes being so fitted that they form a continuous spiral curve This allows the gas to be drawn in at one end of the casing and expelled at the other end Water is admitted at the side of the casing and is converted into a fine spray by the revolutions of the blades, and the spiral arrangement of these

blades causes the spray to flow in the opposite direction to the gas, which passes through this spray, being simultaneously cleaned and cooled. The dirty water leaves the apparatus by a water seal at the bottom.

The Theisen and Schiele systems of final wet cleaning have for years given very satisfactory results, but are now being gradually superseded by systems requiring less capital expenditure and less operating expense. Most of these systems can be used for primary cleaning as well as for final cleaning, by installing in two stages. The most important of the wet cleaning systems which perform as efficient cleaning with the consumption of much less power and water than the Theisen and Schiele systems, are the disintegrator system of Theisen, the disintegrator system of Schwarz-Bayer, the Fowler & Medley rotary washer, and the Feld rotary washer, while the Halberger-Beth dry cleaning system of filtration through canvas is remarkably efficient in cleaning and is cheap to operate. Following is a detailed description of each of the systems mentioned, together with several other modern systems:

THEISEN DISINTEGRATOR GAS WASHER.

There are two styles of Theisen disintegrator gas washers. One style consists of a casing in which the gas enters by two apertures at the base of the apparatus and is washed by a spray of water in a perforated drum or cage equipped with vanes, the drum revolving within a stationary drum, the gas being drawn through the apparatus by a fan mounted on the same shaft and discharged with the necessary pressure to carry it to the point of consumption. The second style also has the fan mounted on the shaft, but the fan is inclosed within the disintegrator.

The Theisen disintegrator consists of a series of rotary and stationary perforated drums or cages arranged concentrically within one another, as shown in Fig. 18. The stationary drums consists of round bars and the revolving ones of angle bars. The hot raw gas enters the apparatus at the bottom, meets the effluent water and undergoes a preliminary cooling and cleaning in the lower part of the machine. The gas is drawn in counter-current through the series of rotary and stationary drums by means of a fan. The water is converted into a fine spray by the centrifugal action of the rotating drums, and the gas, passing through this spray, is cleaned. The fan is located in the same casing and on the same shaft as the rotary disintegrating drums, the shaft being direct motor driven. Fresh water is introduced into the innermost rotating drums in the form of a finely divided spray.

The cooling and cleaning of the gas and production of the pressure necessary to conduct the clean gas to its point of consumption are all performed in one apparatus and with one motor. It is stated that this disintegrator is an improvement over the former Theisen apparatus, requiring much less power and water, and performing the necessary cleaning of the gas without preliminary towers.

(To be concluded.)

"Twilight Sleep" in the Light of Day*

SOME very excellent lay magazines, and some equally good professional ones, have been taking somewhat opposite sides in a discussion of "painless childbirth," according to rules laid down by Drs. Kroenig and Gauss, physicians-in-charge of the maternity clinic, Baden University, Freiburg, Germany.

The treatment is practically an adaptation to obstetrics of Crile's anoci association, that is, it is partly psychologic and partly the administration of drugs to the point of semi-narcosis with the aim of eliminating the memory of pain.

Absolute quiet and very soft light in the lying-in chamber is insisted upon. One hypodermatic injection of narkophen, which is claimed to be less toxic than morphin, is given, and an hour later a first injection of scopolamin into the muscles of the lumbar region. Small doses of scopolamin are repeated at intervals, according to the length of the labor, usually about five doses being given. Advocates of the method claim remarkable results. A few institutions which are properly equipped for the work in the United States have given it sufficient trial to demonstrate that "twilight sleep" *does* act to abolish memory of pain and may be practised without marked danger to mother or child, *but only with every institutional precaution.* Gentlemen who have tried out the German technic do not recommend it as a safe procedure under the usual conditions of a general obstetric practice. Except for the abolition of the memory of pain, and as a luxury to women in confinement, there is, thus far, no sustained claim that the method presents any tangible advantages in the average case of obstetrics.

On the other hand, opponents are severe in their condemnation, claiming danger of the child being asphyxiated, prolongation of labor, and excessive hemorrhage. But perhaps the question of medical ethics involved as regards the kind of publicity employed in exploiting the method had some bearing upon opinion rather sharply expressed.

Despite the fact that medical journals generally were quick to denounce the methods of Kroenig and Gauss, the same journals were equally prompt in commending the made-in-America "twilight sleep," as recommended to be placed in the hands of every doctor who cares to purchase tablets of morphin and hyoscin.

Now, despite many unfavorable reports upon morphin and hyoscin in labor—the journals were full of it a few years ago—there are many physicians using these drugs and claiming good results. They must have a reason for it, just as others have a reason against it. But merely giving morphin and hyoscin is not practicing the "twilight sleep" method; no, not even approximating it!

The fact is that racial differences should modify our obstetric practice, as women of different races present differing problems. No hard and fast rules can be laid down. Some women of neurotic tendencies—pampered, petted, unaccustomed to the hardnesses of life—will welcome the German technic of "twilight sleep." One can readily understand that the method has a legitimate application among a certain class. Also these women should be confined in a special institution, where they can *safely* have the balm of "twilight sleep." And one can understand readily enough that the hard-headed country physician sometimes has cases in which morphin and hyoscin will serve him and his patient. True, if he uses these potent drugs, he should remain a longer time with the patient—charging for his time—so as to be on the safe side, and he should not overdo the dosage. But he should not bluff. Giving a dose or two of morphin and hyoscin is not "twilight sleep," any more than the common but unscientific custom of giving a hypodermatic dose of morphin before anesthesia is "anoci association."

And the blunt fact remains that neither "twilight sleep" nor the administration of morphin and hyoscin in labor is good practice as a routine procedure. Most women need neither one of them. The obstetrical authorities who are opposing these methods are not doing so from mere crankiness.

SURGERY AND ANESTHESIA.

There is a popular demand upon the doctor to "stop this pain!" After all, most of the doses of narcotics we give are given, not because we think the patient needs the narcotic, but because he will promptly go to another doctor if we refuse. This editor may preen himself upon his virtue because he point-blank refuses a narcotic nine times out of ten it is asked for, and loses practice by the many refusals; but the Scotch are good refusers, and it may be bluntness more than virtue. But whatever it is, it saves many a man and woman from themselves. That is part of a doctor's job.

The surgeons are responsible for much of this craze for pain-stopping. Incising a boil for a dollar has given way to the ten-dollar, local-anesthesia surgical operation. "Painless dentists" have the call. Blisters are out of date, principally because they hurt. The man who invents "painless vaccination" will have the anti-vaccinationists on the run in short order. Women who have hair removed from their faces by the electric needle method are now demanding that cocaine first be applied. It is the pain and annoyance that keeps many women from nursing their babies. Ear-rings have gone out principally because it hurts to pierce the ears. Men are not a bit better. Every headache must be "stopped" by a dose of poison and we must soothe our nerves with several cigars a day. Fie on us! We are becoming soft. And modern surgery is helping along in the craze for "stopping" pain.

So, is it to be wondered at that women are asking why it is that normal labor is being made a matter of elaborate surgical technic and without any form of anesthesia, whereas in other surgical work she is fully anesthetized? Years ago, before a labor was regarded as a surgical crisis, ether was given, and we are being asked why its use was nearly abandoned in the lying-in room.

But physicians know the danger of semi-anesthesia. Maybe we have exaggerated these dangers. Certainly we have devised no way to overcome them. And yet it would seem that, in the supreme crisis of a woman's life, there *should* be a way. Let us try to find it. "Twilight sleep" may be a beginning. So, instead of denouncing it, let us try to find out its weakness. Personally disappointed in all methods of anesthesia or semi-anesthesia we have employed in labor, and not at all inclined to view hyoscin favorably, yet we feel that *a way* should be found, even if it is simply some modification of or improvement upon present methods. Meanwhile, let us be charitable to the physicians who advocate "twilight sleep" and hyoscin. If we discover some better way, then our condemnation will come with better grace.

PAIN AND EUGENICS.

But a few general considerations must not be forgotten. If we are to retain our regard for the well-being of the race at large, we will not allow ourselves to be swept off our feet by the ultra-modern fear of pain and the craze for narcotics. Sex consideration is admirable in its way; but child-bearing is not a matter of ordinary sex consideration, because *the race,* not merely the female sex, is most vitally involved in it.

Of course, it is a trial for women to face child-bearing and its pains. Every proper effort should be made to mitigate these trials. But if eugenics means anything vital to the modern women, she will not act the coward and menace the safe conduct of the important function of child-bearing. She will seek for a remedy, but she will also face the issue whether a remedy is found or not.

* The *Medical Council.*

Fastening Metals to Marble

A CEMENT for fastening metal parts to marble, as in the case of an electrical switchboard, which should be most useful, is given in the *American Machinist.* It consists of thirty parts plaster of paris, ten parts of iron filings, and half a part of sal-ammoniac. These materials are intimately mixed and then acetic acid is added to make a thin paste, which must be used immediately after mixing.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, FEBRUARY 13, 1915

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) . . . . " 3.00
American Homes and Gardens . . . . " 3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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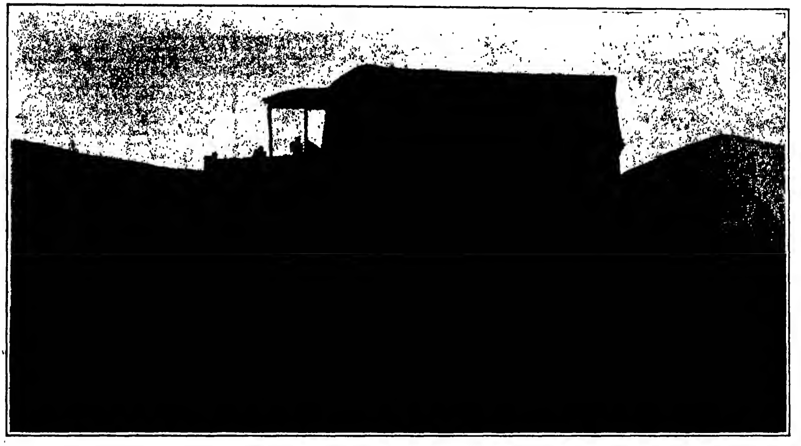
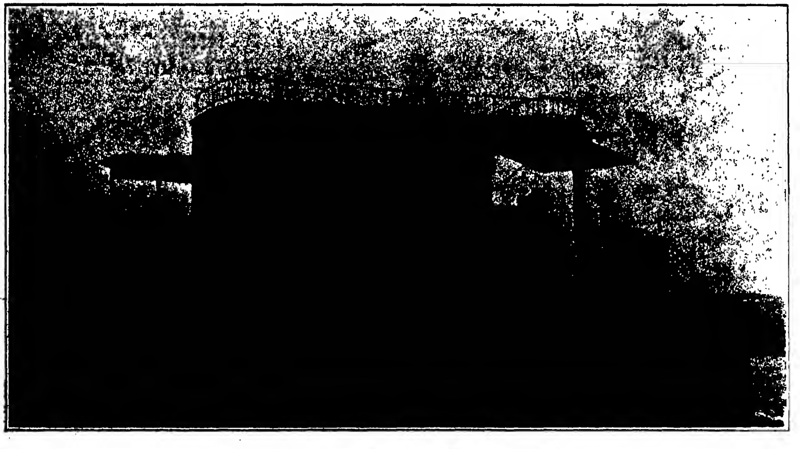
VOLUME LXXIX NUMBER 2043 — NEW YORK, FEBRUARY 20, 1915 — 10 CENTS A COPY $5.00 A YEAR



A motor truck for rescuing disabled cars.



A traveling workshop for repairing aeroplanes, automobiles, motorcycles and gun carriages.

AUXILIARY MOTOR CARS USED BY THE GERMAN ARMY.—[See page 116.]

Aeronautics and the War*

A Review of What Aeroplanes Have Done and of Their Development During the Year

SOME time in the future—in the near future, we hope—it will be possible to review the aeronautical activity induced by the war as a whole, and to comment freely upon the facts then known to us. It is impossible and undesirable to do so at present. With the knowledge of what has been done, as possessed at present, we would be in some danger of drawing false deductions. Even now, we fear there is a tendency in some quarters to mistake the aim and object of the military aviator, a mistake fostered by the tendency of the Press to give undue prominence to certain dashing aeroplane exploits.

It is clear enough already that by far the most important duty intrusted to our flying corps is the collection of information concerning the enemy's movements. Time and again, Sir John French and others have paid splendid tributes to this aspect of our aviators' work. It has been definitely laid down as a guiding principle that this collection of information is to be the main object of the corps. Nevertheless, as the commander-in-chief said in a recent dispatch, almost every day new methods for employing the members, both strategically and tactically, are being discovered and put into practice. What these new methods are we will no doubt learn in good time. But for the present we must be content with the knowledge that in addition to collecting information our aviators are endeavoring, very successfully too, to prevent the enemy's airmen doing likewise. As a means for discovering targets for our artillery and for observing the range and directing the fire generally, they have proved themselves invaluable. In addition, it may be gathered that they are being employed to discover the position of our own troops and their movements and report accordingly to headquarters. This is, of course, not a very sensational occupation, but it is one of the results which can be of the highest importance, particularly under modern conditions of warfare. It is only fair to mention here also the admirable but wholly unsensational patrol work that is carried on unceasingly round our coasts by aeronauts of the naval and military wings.

While bomb-dropping has been effective against Zeppelin sheds, supply and ammunition columns, railway stations used by the enemy, and so on, it must not be forgotten that the effect is usually quite local, whereas the aeroplane scout may do work affecting the success of the whole campaign. Other methods of rendering the aeroplane a means of offence against troops have been suggested and tried, one notable case being the equipment of it with a box containing steel darts for discharge against troops in close formation. We have seen and handled two forms of such darts. In one instance, the missile is merely a steel pencil, with a portion of its length fluted by a milling cutter to give it a tail. In the other case, the dart is more elaborate, consisting of a pointed ellipsoidal head, a small rod-like shank and a tail formed of four plane surfaces disposed at right angles. It weighs under 2 ounces, and during its descent probably reaches the limiting velocity of 400 feet to 500 feet per second, so that its striking energy is, say, about 500 foot-pounds. Reports—from German sources, it is true—quite discredit the effectiveness of this weapon.

As for defence against aerial attack or observation, we may tentatively express the opinion that aeroplane is the best reply to aeroplane. Rifle fire from the ground is practically of no avail. Special anti-aircraft guns have been used and have on one or two occasions succeeded in bringing down their prey, but we have received no conclusive evidence to prove that they are an unqualified success. The aerial duel, romantic as it may sound, seems after all to be the most practical method, and in this connection it is highly interesting to note that according to reliable reports our officers seem to prefer the short service rifle and the revolver to any quick-firing gun yet designed or installed. Defence against Zeppelins falls under a different heading. The huge target presented and the slower speed probably render the anti-aircraft gun the best reply, although on this point we have had no real experience to guide us. Reports have been received on several occasions of Zeppelins being attacked by aeroplanes, and in at least one instance we were told that the aviator gallantly sacrificed himself and destroyed the enemy's craft by ramming it. Our readers should be slow to accept these stories as true. Indeed, Garros' exploit was a pure fiction. The operation would almost certainly not attain its desired end in the case of a Zeppelin or other airship possessing a rigid framework and carrying its gas in eight or more separate ballonets. A much more reasonable and less wasteful method for carrying out an aeroplane attack on an airship is clearly indicated in the incendiary bomb.

It is not a little curious to turn back to-day to the "Aviation Memorandum" issued by the War Office in April, 1912. This memorandum, it may be recalled, definitely established the Royal Flying Corps on its present basis. One of the most striking points about it, as now seen, is the extraordinary estimate of the "wastage" likely to occur in war time in the ranks of the corps. The establishment for the expeditionary force was fixed at 182 flying officers and non-commissioned officers, with mechanics, transport, etc., additional. It was assumed that at the end of six months' war the wastage would be 100 per cent; that is to say, that the whole of the original force would be out of action. It has not, we think, been called attention to before, but the fact is that the casualties among the Royal Flying Corps have been remarkably low. We have now been at war for five months, and as correctly as we can discover our casualties have been as follows:

Army:	Killed by the enemy	4
	Killed accidentally	2
	Missing and prisoners	5
	Wounded	5
Navy:	Killed by the enemy	2
	Killed accidentally	3

In addition the naval air service lost two killed and three wounded when H. M. S. "Hermes" was sunk and suffered four wounded in transport and armored motor car work in Belgium. Counting all sources, therefore, the army has lost six and the navy seven of its airmen or mechanics. We do not know what the total aerial force attached to the British army or navy now is, but the *Gazettes* have shown us that since the war began the ranks have been enormously increased. We may doubt, therefore, if the casualties have amounted to more than 2 or 3 per cent. The figure is certainly very much smaller than that for the other branches of the army, so that it appears that the air service during war time is one of the safest to be in. This remarkable and significant deduction is, we may add, confirmed by the reports of some of our aviators, who frankly admit that from the point of view of safety they distinctly prefer flying to occupying a place in the trenches. Knowing all that they have done, their arduous duties, their daring exploits, could there be a finer testimony than this to the excellent construction of our machines and the skill with which they are handled?

In the same memorandum as above referred to some hesitation was manifested in assigning a definite rôle to the naval aeroplane and the organization was left correspondingly elastic. Since then we have progressed considerably. Seaplanes have been rapidly developed, and we have now a Naval Air Service that has been evolved along organized lines from the old naval wing of the Royal Flying Corps. Nevertheless the seaplane or hydro-aeroplane has not taken—or rather, has not been announced as having taken—any conspicuous part in the war so far.[1] This is almost certainly due to the fact that opportunity to do so has been lacking. During the transport of the expeditionary force to France in August airships and aeroplanes—presumably seaplanes—kept watch and ward over the Channel for the approach of hostile craft. It is possible, too, that the aircraft that directed our monitors' fire against the German right on the Belgian coast included some seaplanes. Beyond this we have heard of nothing being done with these craft, although, of course, our seaplane bases round the coast have without doubt been engaged on useful patrol and other work. Our naval aviators have not, however, been idle. They have found a congenial occupation piloting land machines and armored motor cars. The raids on Cologne, Düsseldorf, and Friedrichshafen were all conducted by naval airmen. Still, these facts seem to lend strength only to the suggestion that the naval aeroplane for strictly naval purposes has a much more restricted field of application than its military sister. Indeed, when we read that during the twenty days preceding September 10th our military machines made daily an average of more than nine reconnaissance flights of over 100 miles each—and this may be taken as an indication of their activity since—the inactivity of the seaplane seems to amount in comparison to something approaching failure. In writing thus we wish to express no final opinion, for we are well aware that we have not yet heard all that has been accomplished by our aircraft and that no final judgment can be passed on anything, let alone such a highly complex and technical subject as military and naval aeronautics until the war is well over.

AERONAUTICS IN 1914.

Taking the question of general design, the year has witnessed several fairly wide departures from ordinary practice. While generally standard monoplane and biplane construction has become crystallised around a few departures of detail, there are signs that other possible types of flying machine are attracting attention. The helicopter idea, for instance, is not yet dead, as witness Mr. J. R. Porter's continued activity with his direct lifting parachute machine.

But to confine attention to machines following the aeroplane principle, we may note the construction at the Ponnier Works, in France, of a four-winged monoplane. The two pairs of wings in this machine are arranged in tandem, the front pair having a dihedral angle between them and securing lateral stability, and the rear pair being vee-shaped in plan, as in the Dunne machine, and securing longitudinal stability. Fitted with a 70 horse-power Gnome engine, this machine, under test at Rheims, is said easily to have lifted a useful weight of 1,400 pounds.

As is well known, Mr. A. V. Roe and some others in the early days spent considerable time experimenting with triplanes. Although complete failure did not result, at least in Mr. Roe's case, the idea was generally abandoned. It is difficult at the best of times even now to combine structural strength in a biplane with non-interference of one wing on the other. Still more so must it be in the triplane. Yet as the loads to be carried increase a time will soon come when the biplane formation will result in an impracticably great span and resort will have to be made for purely constructional reasons to the triplane or other formation. It is therefore interesting to note that a successful triplane machine has been demonstrated during the year. This is the Euler hydro-triplane or flying boat, manufactured at Frankfort-on-Main. The top plane of this machine has a span of 46 feet, the middle of 33 feet, and the lower of 26 feet. The three planes, to avoid interference, are very much staggered, the top plane considerably overshooting the middle and the middle the lower. The machine is propelled by a 100 horse-power Gnome engine. We have no record of its performance.

While discussing type variations an historically interesting fact may be noted. On May 6th, 1896, Prof. S. P. Langley of the Smithsonian Institute, Washington, had the satisfaction of seeing his model aeroplane flying for three quarters of a mile against a wind. This machine was of the four-winged monoplane type and was propelled by two screws driven by a steam engine weighing 6¼ pounds per horse-power. A subsequent large-sized copy of this machine, intended to lift a pilot, was constructed, but failed. During the past year an exact duplicate of this machine as preserved at the Smithsonian museum was constructed and fitted with a 90 horse-power Curtiss motor. With a slight reduction in the angle of incidence of the wings and the addition of a hydroplane for starting an American aviator, in September, succeeded in flying it nearly 2,000 yards. Langley's position as a pioneer of flight, sometimes doubted, has thus definitely been established.

Leaving the development of type for the development of detail, we can touch only upon one point, namely, the vexed question of stability. The progress made in this direction has not been as great as we should like to see. It is undoubted that so far as automatic stability is concerned, there is a prejudice against it among pilots, and that this prejudice is hindering progress. They object, it seems, to carrying more machinery than is absolutely necessary, and looking at some of the complicated and delicate devices which have been proposed for attaining automatic stability, our sympathies are entirely with them. They maintain, too, that no device yet proposed secures stability under all conditions, and that at times, notably when landing, the stability must be under the direct personal control of the aviator, with the intervention of the least possible amount of machinery.

The Sperry gyroscopic stabilising device has already been described in these pages, and may be taken as typical of many proposals. Equally typical of another class is the Wright system, to which much attention has been directed during the year. In this the controls are arranged to be operated by a compressed air motor,

[1] These remarks were written before we received the news of the Cuxhaven seaplane raid.

* From *The Engineer*.

The action of this motor is in turn controlled by a vane when the longitudinal stability is upset and by a pendulum when the lateral stability is affected. The use of a pendulum for this purpose has often been proposed, but it is unsatisfactory because of the tendency of the pendulum to swing to its maximum amplitude independently of the magnitude of the displacement to be corrected, and to keep swinging when the machine has been righted. In the Wright apparatus an electrical contact system is employed to correct these deficiencies.

As for inherent stability, progress toward a completely satisfactory solution is still in the experimental and mathematical stage, although, of course, there are many machines in existence which give a fair degree of inherent stability under certain conditions. The ordinary dihedral angle between the wings of a machine is intended to secure partially at least inherent lateral stability. As a development of this, we now have, as in the Curtiss system, a stabilizing disk, with its lateral edges turned up, mounted well above the upper main plane.

The Making of Large Guns

Some Details and Methods of Constructing Modern Weapons

There has been so much in the daily news reports about the "big guns" and what they do, that there is a natural curiosity among a large element of the community to know how these remarkable weapons of modern warfare are constructed. To such the following description of the methods of procedure in building of big guns in England, which we find in the Engineering Supplement of the London *Times*, will be of interest.

From the point of view of the machinist the manufacture of ordnance has three aspects—the large numbers required, the peculiar and special shapes of many portions, and the exceedingly fine degree of accuracy which is absolutely essential. The large numbers required affect the methods of manufacture adopted. There is, of course, an immense difference between the numbers in which the smaller artillery and the relatively few big naval guns are built, between say, the Maxims and the 12-inch or the 15-inch guns. Yet for all alike the shop methods adopted are those which are now generally recognized as processes in which jigging and gaging are essential. When in war a piece of artillery is thrown out of action by the removal or damage of some essential part, it is of the first importance that it shall be renewable without the help of the skilled mechanic. This involves a degree of refinement in measurement which exceeds even that adopted in ordinary engineering works. The highest grade of interchangeable practice is therefore essential to insure the best results; and all the methods which are available to secure these results are freely used—jigs, special drills, boring tools, reamers, cutters, and gages and micrometers. Even when parts have to be finished by hand they are checked and tested by means of fixed gages. Any part of any one type and size of artillery will then take its place in any individual of that type and size.

Again, the peculiar and special shapes of many portions have been the cause of the design of many special machine tools which are used for no other purposes and the details of which are not permitted to be published. Probably one half the tools are either of this character or else they are standard designs greatly modified. In many cases two or more operations are done on the same piece simultaneously. The accuracy required involves not only the jigging and gaging already noted, but also a most elaborate system of testing before the various components are passed to the assemblers and erectors. This work is done in special shops by skilled men who are provided with very delicate instruments and appliances.

METHODS OF BUILDING-UP.

Ordnance in this country is constructed by reinforcing the actual gun tube with rings shrunk on. Two systems are in use, one with, the other without, wire winding. The latter is reserved for the heavier guns and chiefly for naval service, and it affords a very refined method of securing annular increments of tensile strength corresponding as nearly as possible with the stresses which are imposed by the discharge. The wire also reinforces the gun tube so that in most cases the tube will safely endure the enormous stress of 17 tons to the square inch. The steel in the wire is of about double the tensile strength of that in the tubes. The difficulties of shrinking on tubes to secure uniform stress, even though they are divided up into comparatively short lengths, are greater than those of winding wire. If the tube should crack or develop a fault it may still be fired. In the event of an explosion of a shell in the tube the wire winding will prevent grave disaster. A faulty tube can be more readily replaced when wire-wound than when the gun is built up solidly. The illustrations give sections through the two types of guns. The solid gun is seen to be built up of tubes wholly. These are clearly shown, and the jacket, each one shrunk on its predecessor. In the wire-wound gun there may be one or two tubes over which the wire is wound, and the jacket tubes are shrunk over the wire. A bush for the breech plug is screwed into the rear end, which is also reinforced by a breech ring outside.

MACHINING OPERATIONS.

The enormous stresses endured by the built-up guns would not be possible but for the extreme care exercised in the preparation of the steel and in the heat treatment—the annealing and hardening to which it is subjected. The steel is melted in open-hearth furnaces and the metal is poured into solid octagonal ingots. The first machining operation is that of trepanning or boring a hole through the ingot, and is preparatory to the forging. For large ingots the boring bar is rotated, but small ingots are rotated round a bar which does not rotate, but is fed forward. A mandrel is thrust through the hole, while the tube is worked under a hydraulic press to diameter and length. The mandrel is hollow to permit a stream of water to be forced through it to keep the central part cool. Rough turning and boring follow. The largest lathes are used for the gun tubes. The lengths vary with the size and class of gun. The beds range up to 90 feet and sometimes more in length, and height of centers varies accordingly. Generally these lathes have two saddles. They are driven by independent electric motors. Rough boring is done on other machines, the beds of which are long enough to permit of boring from each end simultaneously. Similar operations are performed on the gun tubes and the jackets, but on different machines, each of a length and height of centers suited to the particular work put upon it. In some machines two tubes will be bored simultaneously. An important operation follows, that of hardening or tempering in a bath of oil. The resulting hardness and tensile strength have to pass strict specified tests before any more work is done.

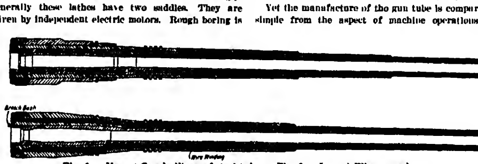


Fig. 1.—(Upper) Gun built up of steel tubes. Fig. 2.—(Lower) Wire-wound gun.

WIRE-WINDING.

From this stage the guns are constructed on one of the two systems named, that of plain tubes and jackets, and that of tubes wound with wire before the jackets are shrunk on. The tube is rotated in a lathe, and the reel off which the wire is wound is mounted on a carriage that is traversed along a bed at the front of the lathe bed proper by means of a screw regulated to synchronize with the rate of revolution of the lathe. The wire is secured at the breech end by being wedged in a recess, after which the winding proceeds along to and fro alternately. To vary the tension that is put on successive layers the wire is nipped between dies of hardened steel pressed in contact by a series of levers and weights adjusted to suit the varying tensions. The tension is diminished in each successive layer. The windings are least at the muzzle and greatest at the breech; in a 12-inch gun they number 12 and 75, respectively. The wire is flat—of ribbon section—about ¼ inch wide by 1/10 inch thick. Its tensile strength is very high, 100 tons to the square inch. A 12-inch gun requires 117 miles, with a total weight of about 13½ tons.

necessary to remove inequalities in readiness to receive the jacket tubes, which are bored to be slightly smaller than the outside of the wire, so that they may be shrunk on. In a tube which is not wire wound the same process is adopted.

When the inner tube consists of two portions, the inner one is slightly tapered on the exterior and also provided with a number of shallow shoulders. The interior of the second tube is bored to correspond with a diameter very little less than that of the one over which it has to be shrunk. It is then heated slightly and the inner tube thrust into it up to the shoulders.

As these shrinking-on operations have to be done with the guns suspended vertically, very deep pits are necessary, partly sunk into the ground and partly built up about it. The heating is effected by gas jets surrounding the jacket. Water taps are provided for use if required for cooling. After the shrinking on is completed the outside is skimmed over in the lathe, and the machining of the keys for the slides of the mountings and the lugs for the breech-block hinge follows.

RIFLING.

The rifling of the bore succeeds, and is done in machines designed for that purpose only, the bar being traversed and rotated to synchronize with the pitch of the grooves. The rotary movement is effected by a pinion on the end of the bar turned by a rack, which is actuated from a templet bar. In long rifling change-gears would be impracticable. In the subsequent examination the accuracy of the bore and rifling is tested by inserting plastic gutta percha. The interior is illuminated with mirrors to detect defects, if any. The exterior is examined while the guns are rotated on roller bearings.

CONSTRUCTION OF THE MOUNTINGS.

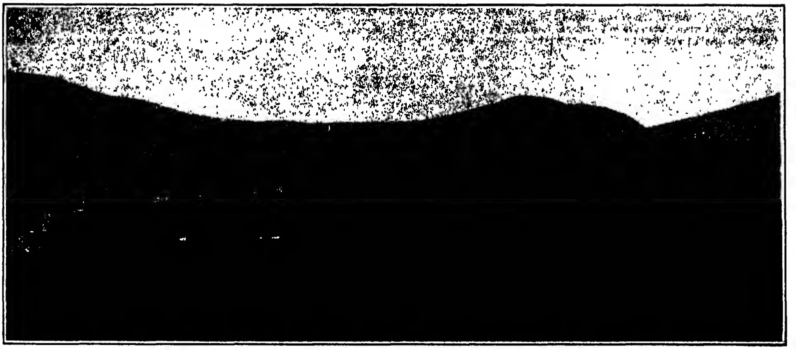
Yet the manufacture of the gun tube is comparatively simple from the aspect of machine operations when compared with the component parts of the gun mountings. Excepting in their proportions and dimensions and the differences in wire-winding and building up without wire there is no essential difference between the small and the large gun tubes. All are built up, all are breech-loaders. But the mountings are totally unlike in land artillery and naval ordnance, and in small and large guns. In a Maxim there are about 280 separate parts, entailing about 550 distinct operations done on machines, apart from the fitting. For the 0.303 Maxim about 950 gages are used and the parts are all interchangeable—are within the limit of 1/5,000th part of an inch. On a 6-inch gun there are about 100 parts in the mechanism of the breech alone. The work on the pom-pom gun involves about 770 operations by machine tools done on 400 parts. The amount of tooling entailed on some pieces reduces the weight by one half or more. The lock frame for this gun weighs as a drop-forging 25½ pounds, but only 10½ pounds when finished. Some parts require 27 distinct milling operations, each one being tested by gage.

The breech of a gun is a marvelous piece of mechanism, most of the machining of the parts of which is done on special machines. The bush and the block are prepared from forgings long enough for some twenty pieces to be cut from it, and these are hardened and subjected to tests before any actual work is done upon them. Hardness and strength are essential for two reasons—one to offer the maximum resistance to the stresses of discharge, the other to lighten the parts as far as is consistent with safety. All the movements of the block are accomplished by the movements of a single lever in the smaller guns, of a handwheel in the larger, by means of mechanism contained in and about the block, and this detail is a vital element in the quick firing of guns, the importance of which is well understood in modern warfare. Another aspect is lightness.

QUICK-FIRING AND AUTOMATIC GUNS.

All guns now are quick-firing, but relatively few are automatic. The distinction is this—in the first the breech is opened and closed by lever or hand wheel with remarkable rapidity, in the second the energy of the recoil operates the mechanism. In England the Maxims and the pom-poms are the examples of this latter group. In these the breech-block is not screwed, but slides in a vertical plane between guides, a spring and a lever operating it alternately. The pom-pom will fire from 250 to 300 rounds a minute. Each shell weighs about 1¼ pounds and bursts into a dozen pieces. The Maxim will fire 800 rounds a minute, and its projectile weighs 1 ounce. A 6-inch field gun carries a 100-pound projectile. A 12-inch naval gun fires an 850-pound shell, a 15-inch gun one of 1,950 pounds.

Fuel supply tank car for motor transport service.



A rescue car with sides fitted, and a car for carrying parts for replacement.

Auxiliary Military Motor Cars

Various Kinds of Cars That Have Been Developed to Meet Requirements of Armies in the Field

The German army department, in conjunction with the Benzwerke Gaggengau, have designed a number of military vehicles which on account of their special utility are of great importance. Those auxiliary motor cars are kept at the instant disposal of the army in order that in the event of any breakdown of other motor vehicles they can immediately come to the rescue, and they also serve to replenish stores of fuel, oil and water.

Their duties also include keeping the military vehicles of all classes in permanent working order. These cars each comprise a Benz chassis with such alterations and additions as are required for the special purpose for which each is intended. Each machine is driven by a 44.50 horse-power four-cylinder motor, and extra large radiators are fitted, so that even when the vehicles are stationary there is sufficient cooling effect for continuous running of the engine.

There is a motor-driven tank wagon provided for the transport of supplies of fuel, water and oil, and the tank therefore is divided into three compartments. The front and rear compartments contain respectively oil and water, the large central chamber being reserved for gasoline. The gage glasses and a gasoline meter show the amount available in each compartment at any moment, while pumps are fitted by means of which the contents of each compartment are conveyed through flexible hose pipes to the cars requiring replenishment.

As shown in an accompanying illustration, another motor-driven military car has been designed intended for the transport of a complete stock of replacement parts including tires. The tires and larger parts are carried in a central compartment, while the smaller articles are stored in bins on either side of the vehicle. Each bin can be locked, while a special device enables all bins in any row to be closed and locked simultaneously.

There also has been developed another auxiliary motor vehicle intended for carrying bodily a car which may be temporarily disabled, thus preventing its capture by the enemy. This vehicle has an exceptionally long wheelbase and frame to take an extra long platform body fitted with removable sides about 20 inches high. These sides are each fitted with a folding truss, and can be used to form ramps up which a disabled vehicle can be rolled onto the platform. This operation can be performed with little loss of time, as the rescue vehicle is provided at the rear with a winch

(driven by the power of the engine) from which a steel cable is attached to the disabled vehicle. The platform of the rescue car is also so equipped that a crane can be installed and utilized for picking up a vehicle that may be too seriously disabled to be hauled up the ramp as described above.

The military workshop car shown in one of the illustrations is of the greatest importance for the keeping in order of aeroplanes, military motor-cycles and gun carriages as well as other motor vehicles.

As will be noted in the photograph, a complete outfit of machine tools and appliances has been installed on the car, comprising a lathe, shaper, band saw, a smith's furnace and anvil, a machinist's bench, a carpenter's bench, and a grinding machine. At the rear end of the chassis is installed an entirely inclosed direct-current dynamo with an output of 6.6 kilowatts, and driven from the gear box of the vehicle by means of a special shaft and clutch. This dynamo supplies the current to the individual electric motors fitted to each of the machine tools. The shop is also electrically lighted.

It may be stated that the walls of the shop are divided longitudinally and the lower halves are provided with adjustable legs, thus providing additional working space; while the upper halves of the sides furnish shelter. A rail fitted round the top of the roof furnishes additional storage for material. With the equipment here described the various fighting machines of the army may be kept in working condition in the field, when without such travelling workshops much of the military apparatus when once disabled would be useless or have to be abandoned.

The Preserving of Food Products*

MILLIONS of dollars is a lot of money. When invested in perishable foodstuffs, the market value of which fluctuates, and supplying the most densely populated section of this continent, the problem of preserving these products is one of great economic and engineering importance. We will consider only the engineering part of the problem.

Right here, the writer wishes the reader to understand that in this plant uninterrupted service is paramount. To shut down is unthinkable.

Service is sold on a guarantee that the temperature will not vary more than one degree. Suppose the plant fails only for a short time in summer; then the temperature rises and hundreds of thousands of dollars' worth of produce may be ruined. The dealer can claim damages for his loss, and there is always the possibility that, should the service fail and the temperature rise considerably at a time when the market value of the produce is going down, with every indication that it will not rise soon, the dealer might sue, claiming injury to his produce, and thus try to recover a loss or avoid an impending one. Where over 800 customers are served on the street system alone and seventeen large warehouses are filled with perishable goods, as is the case in a large plant in Boston, the damages due to service interruptions would be large.

Service interruptions are as much to be feared as in electric central-station or railway practice, either of which can drop its load and pick it up where it dropped it. A refrigeration station cannot do this. The moment service ceases, the temperature begins to increase, and by the time the plant is again in service, the temperature may have risen so high as not only to damage the goods, but—and here is the point—to require hours to get it back to normal.

Differing from electric or railway station practice, the load is practically constant 24 hours a day for whole seasons. From the viewpoint of overall station economy, this may be desirable, but where real estate values are high and the station's capacity is none too great for the maximum demand, the equipment must go into service prepared for a nonstop run of months. Every feature of operations, every detail of design must be planned to this end, and should an accident occur, the exigencies demand that the crew be capable of getting the machine back into service with the least possible delay, which means that it must be, to a great degree, independent of outside aid except for very exceptional cases.

* From an article on the Equipment and Methods in the Largest Refrigeration System, by Charles H. Bromley, in *Power*.

High Explosives in Warfare*

Interesting Facts Relating to Their Composition and Action

By W. Macnab

AT the present time explosives are playing such a prominent part in the war that the interest and attention of the most peace-loving citizen are necessarily aroused by the terrible results undoubtedly produced, or are more morbidly affected by the tales of the alleged marvelous effects which are yet to be experienced. A few notes on the most important explosives being used in war may therefore be of special interest just now.

The explosives which can be advantageously employed in warfare are by no means the most powerful which the chemist can produce, or which may even be used in civil engineering or mining operations. The military high explosive must be sufficiently insensitive to shock to prevent its being exploded when struck by projectiles, or when submitted to the shock of being fired from a gun as the charge of shell, else it might prove as dangerous to the user as to the enemy. Thus, the nitroglycerine class and many other explosives are excluded.

For many years guncotton, containing a considerable amount of moisture, was largely used for naval and military purposes. In the moist state it is extremely safe, but can be easily detonated when a small primer of dry guncotton is fired in contact with it. The explosive effect is great, and it provided an excellent and safe explosive for military mines and purposes of destruction, and as a charge for torpedoes. It was not, however, suited for use in shells.

The high explosives chiefly being used in the present war for shell-filling are picric acid, trinitrotoluol, and ammonal. Picric acid, with or without the admixture of various ingredients, has been in use at one time or another in most countries under the names of mellnite, lyddite, shimose powder, etc. Until picric acid came into use, black gunpowder formed practically the only explosive used as a bursting charge for shells, and the use of picric acid was a great advance from the destructive point of view, as its explosive power was very much greater. Picric acid, although sufficiently insensitive to shock, has the property of readily attacking metals and forming picrates, which are much more sensitive and liable to explosion. This involves special precautions in dealing with it, and is a disadvantage.

Ammonal is a mixture consisting of ammonium nitrate, trinitrotoluol, charcoal, and aluminium in fine powder. It is very safe, and is more powerful than picric acid, but owing to the hygroscopic character of ammonium nitrate, its chief constituent, it has specially to be protected from moisture, which reduces and, if in sufficient quantity, destroys its power of explosion. It is largely used by the Austrians.

Trinitrotoluol is undoubtedly now the most widely used high explosive for military purposes under the names of "Trotyl," Tritolo," "Trolite," "Tritol," "Trilite," and "T.N.T.," according to the nation using it.

"T.N.T.," as it is called in the British Service, has attained its position by virtue of its merits. It is used in a state of great purity; it is chemically stable and without action on metals. It is unaffected by water, and can be fused and run into shells in the molten state. It is less sensitive to shock than picric acid. Hard blocks of suitable size and shape are covered by electroplating them with a coating of copper, which prevents the blocks from being broken and having their edges chipped. In this form "T.N.T." is used for demolishing bridges, etc. Although not quite so powerful as picric acid, its other advantages make it at present perhaps the best available explosive for military use.

The destructive effect of an explosion is caused by the almost instantaneous conversion of the solid explosive into gases, at a very high temperature, with consequent sudden exertion of an enormous pressure. From the purely disruptive point of view, the composition of the gas produced is not necessarily of importance, the determining factors being the volume of gas, the heat produced, and the velocity of detonation. When, however, an explosion takes place in a confined space, then, in addition to the disruptive or shattering damage, the components of the gas produced may have an injurious effect on anyone having to breathe it.

In the case of explosives for use in civil life, as in mining work, care is taken by adjusting the composition of the explosive that the gases produced shall not have a deleterious effect on the miner. In military operations this consideration does not arise; indeed, it may be maintained the more deadly the effect of the fumes the better.

Picric acid and "T.N.T." are definite chemical bodies, but owing to insufficiency of oxygen are not completely converted into gas on explosion, a considerable amount of carbon being set free. This accounts for the black smoke which is seen when these bodies are exploded.

In the earlier determinations, when explosives which contained insufficient oxygen for complete oxidation of the carbon and hydrogen were fired in a closed bomb, and the resulting gas analyzed, it was found that its composition was affected by the density of loading. The higher the density of loading the higher the pressure, accompanied by increase of carbonic acid and decrease of carbonic oxide. Methane, which was absent or only in very small quantities at low densities of loading, increased steadily as the pressure increased. It was, however, recognized that the composition of the gas so found did not necessarily represent the composition at the moment of explosion, for the analysis was made some time after and when the gas had cooled. Consequently reactions had probably been taking place during the process of cooling. Finally, it was thought that the formation of methane was not a real result of explosion, but was due to secondary reactions during the cooling stage. The experimental difficulties of catching and fixing the gases at the moment of explosion were overcome by detonating the explosive in its own volume in a lead or porcelain bomb placed inside a larger evacuated steel bomb. The explosive had in this way to do work in bursting the smaller bomb, and the rapidity of cooling of the gas was thus so greatly increased that secondary reactions practically did not take place. When fired under these conditions, which correspond closely to those which exist when a shell explodes, the gases from ammonal, picric acid, and "T.N.T." were found to contain only small quantities of methane. In addition to carbonic acid, nitrogen, and hydrogen, ammonal contained about 24 per cent, and picric acid and "T.N.T." nearly 50 per cent of the poisonous carbonic oxide. It is thus evident that where shells burst in confined spaces, in addition to the damage caused mechanically, those persons breathing the fumes may be fatally poisoned or seriously effected physiologically.

It has been suggested that the ingredients of shell charges may contain deadly poisons, but it seems improbable that any poison intentionally added to the contents of a shell would retain its toxic properties after the shock and heat of explosion. As seen above, the gases from the explosives now in use may be sufficiently poisonous under certain conditions.

The subject of explosives seems often to create a state of credulity, and to generate extravagance of statement on the part of the non-expert writer rarely effected by other matters. The unknown sometimes becomes truly appalling under his imaginative pen. Even inventors have been known to make wild statements in regard to their explosives! One should only accept with very many grains of salt the sensational statements which have appeared in some quarters as to the weird and deadly effects of recently invented explosives. It is well, therefore, not to have exaggerated ideas of the power of explosives or to be unduly scared by the threat of explosives dropped from Zeppelins. The destructive effect of the large charges which can be fired from the huge howitzers used in the present war is terrible, but explosives have their limits.

While without doubt the damage done locally from the explosion of a large quantity of any explosive which might be dropped by a Zeppelin would be appalling enough, yet, judging from the effects of the accidental explosion of a couple of tons of nitroglycerine during manufacture, its area would be comparatively restricted, and the horrifying suggestions mooted of the coming total destruction of cities by explosives dropped from the sky may be ascribed to the imagination of the over-credulous.

* From *Nature*.

Winter Wireless News Service to the Magdalen Islands.—These islands lie in the middle of the Gulf of St. Lawrence, and the inhabitants have no mail, and hence no newspapers, during the winter. Accordingly the Canadian government is sending a wireless dispatch of 800 words weekly to the clergy of the island, giving the latest news of the war and other events, to be communicated to the islanders on Sundays.

Training for the Municipal Service*

How Public Business is Conducted Efficiently and Without Waste in German Cities

By Clyde Lyndon King[1]

"We have conquered upon the field of battle in war; we are now conquering upon the field of battle in commerce and industry." Such was the watchword which Crown Prince Friedrich gave to Germany at the inauguration of the Museum for Industrial Art in Berlin the day after the treaty of Frankfort, closing the Franco-Prussian war.[2] And Germany has conquered in commerce and industry. One reason for this conquest is that her schools have adopted in effect the standards recently set by the South German Educational Congress: "The state must aim at the diminution of commercial waste by insuring that all occupations, however mean, shall be practiced by men who have been trained to do their work scientifically." After diminishing waste in the occupations, German efficiency is now doing away with waste in the public's business due to inadequately trained and improperly equipped public officials and employes.

Four factors may be singled out as being responsible for the tendency toward sustained and thorough, yet specialized and practical, preparation for municipal service in Germany.

The first of these is the rapid rise in urban populations. In ten years the population of cities of over 100,000 increased 50 per cent. Half of the German population are now urban residents. This enormous increase in urban populations means an increase in public functions assumed by city governments many times greater than the increase in population. This increase in public functions requires efficiency and training of public employes.

Preparation for governmental positions in the state has been provided for in the state universities. These institutions are under the domination of practically the same group of officials that control the state administration. Thus, while state positions are amply prepared for, at least in certain of the universities, though German universities, like many American universities, have been all too slow in adding courses in the political, social and economic sciences, adequate to preparation for the highest public positions, these state institutions do not tend to give the specialisation and the emphasis upon municipal service demanded by urban needs. This inadequate training of municipal officials and employes, with its accompanying lack of proper specialisation and proper adaptation, caused a demand for local institutions that would offer the training necessary and adequate for municipal employes. This is the second factor tending toward the creation of municipal colleges for the preparation for municipal service in Germany.

The burgomeister and the paid expert advisers in the magistrat were, as a rule, well trained at the state institutions. But no special training was provided for the great rank and file of city employes, the efficiency of whom, after all, decides the skill and utility with which the taxpayer's money is spent. The need for training well every municipal employee, so that there will be no lost motion through inadequate preparation for positions, is the third factor leading toward adequate public training for public service in Germany.

The fourth factor lies in the fact that public service is a recognized profession of dignity and permanence in tenure. The oft-repeated assertion that there are no politics in German city positions is far from accurate, for in many cities an avowed member of the social democratic party could never be ratified for a leading city position no matter what his worth, while a conservative of the landed gentry point of view would be ratified no matter how incomplete his preparation. But in Germany the provincialism characteristic of so many American cities, which brands experts from other cities or states as "outsiders" or "aliens," finds no place. The result is that a public employe with adequate qualifications, who finds himself blocked in one city because of his party affiliations, can look toward employment in other cities. A position once secured, a tenure for life or for a term of 12 or 24 years, is assured, followed by a pension at the end of service. Moreover, promotion is made from city to city, so that there is no limit to the economic returns and social prestige of the public official of competence and skill. Even the burgomeister and all the leading expert advisers in the magistrat are chosen at will from other cities. The salary, moreover, is adequate to attract the best talent, and increases in remuneration follow at specific intervals. The national laws frequently provide that appointees to certain positions shall have stated professional qualifications, but all examinations are qualifying and not competitive. The state examinations merely determine eligibility and within the large list of eligibles the magistrat has full discretion in choosing officials.[3] Probationary periods of service, promotion on the recommendation of superior officers, with due regard to merit and experience, security of tenure, protection against arbitrary dismissal, exclusion of civic employes and officials from all participation in election campaigns, all these features of American civil service find a place in the German system. But the arbitrary provisions characteristic of American civil service, such as that the appointing official is limited in his choice to the three highest, finds no place in the German régime. The result is freedom of choice by an employing official who must have the best talent and get the best results within his expenditures, for pressure of the tax is as keenly felt in German cities as in American cities.

The fifth factor making for the inculcation of efficiency principles in the German municipal service is the fact that the great public utilities such as the street railways, gas and rail waterways, are publicly owned and operated. This means that not only the best paying positions, but also the positions carrying with them social prestige and honor, are within the gift of the state rather than in the power of private corporations. The youth of capacity and training turns, therefore, by preference to the public service.

The technical training required for the municipal expert in Germany is usually afforded by some branch of the regular educational system.[4]

In the first place, there are the great technical universities everywhere maintained by the individual states, in which technical training of the most definite and specific kind can be obtained for either public or private expert work. At the present time there are eleven great scientific universities, the organisation of which is under the control of the several states of the German empire. The regulation of industries, however, is within the jurisdiction of imperial laws which have established nation-wide standards as to certain technical experts. These laws, for instance, prescribe the qualifications of persons who wish to carry on particular industries, prescribe the powers and duties of the guilds, and require workers to attend continuation schools where such schools exist. The licensing of certain occupations is under imperial control and attendance at some technical schools is practically necessary for those who wish to pass the required state examinations.

Below the highest technical institutions are two grades of machine trade or mechanical engineering schools,[5] those providing for the training of engineers, constructors, foremen, machine draftsmen, etc., and those of a lower grade which train machinists, mechanical draftsmen and technical officials of middle rank and others preparing for positions that require a less highly developed technical ability. To both these classes of schools are often added Sunday and evening courses, open to workmen who cannot afford to give up work entirely and attend school.

But general school training can not make the efficient employee. There are at least two other prerequisites. The first is specific preparation of a kind that could not be expected in a general university, and the second is particular training for those who are employes and officials in municipal service. To meet these two needs a number of strictly municipal institutions have sprung up in Germany. These schools include the special training schools for employes of certain departments, such as the training school for policemen and the college of town planning in Berlin.

A definite movement for local municipal colleges is on foot in Hamburg, Frankfort-on-Main, Cologne, Dresden and Posen, and the small towns of Altdorf, Willenberg and Helmstedt, all three of which had their own universities in the past and want them renewed.

Cologne has opened an academy whose purpose it is to rescue municipal government from academically trained doctors of law. The curriculum includes definite instruction in social politics, in housing and land questions, in the labor problem, in municipal law, in municipal taxation and finance, in public charity, in care for children, in statistics, in school law.

The work and functions of these new universities can best be expressed by a special study of two of them rather than generalized comment on all of them. For this purpose are chosen the Akademie fur kommunale Verwaltung zu Düsseldorf and the Erste Preussische Verwaltungs-Seminar zu Aschersleben.

The purpose of the academy for municipal administration in Düsseldorf, opened for work in the autumn of 1911, is to strengthen and broaden the knowledge of and to offer a scientific and practical training to municipal officials, and to give business-like, scientific and practical education to persons intending to enter the municipal service. A survey of the courses offered and the methods employed indicates that the academy is primarily an institution for the further training of the higher municipal officials.

The courses offered include the following subjects: Rights of taxes; constitutional rights; governmental rights; the police power; social questions; school and sanitary administration and legislation; insurance law; finance; economics; political science; sociology; the resources of the country; national economy; the lawful rights of government; the organisation of city, state and nation; efficiency in government; the science of finance; money and banking; municipal utilities; statistics; building regulations and administration; the cultivation of prosperity and of refinement; the labor question; relief of the poor; business law; practical work in administrative law; municipal finance, constitutional law; taxation law, criminal law and procedure; the poor law; the science of work in business; labor union laws and their interpretation; criminology, and bookkeeping.

The analytical, practical and thorough character of the courses offered may be gleaned from the content of selected courses. Thus the course in the science of law includes the foundation principles as to the rights of citizens and the rights of officials; purchases, leases, deeds and their characteristics; indemnity obligations of the community; earnings and laws of properties; real estate law, rights of mortgages, the authority of parents and the power of the respective governments as guardians; the rights of associations and of business; commercial law; the foundation principles as to state, rural and city administrative law; the constitution of the state of Prussia, the Imperial constitution, the rights of administrative organs of government, the police power and the general position of the police, including the safety and sanitary police. The course in taxation law includes discussions of the various kinds of taxes, such as professional and occupation taxes; concessions; beer, dog, amusement and other indirect general taxes; double taxation; the increase in taxes and the value thereof; the relation between city, district and provincial taxes. Insurance law includes a history of public insurance, the details as to sick, accident and invalid insurance, the relation of the insured to each other. The course in statistics includes discussions as to the nature of statistics, statistical methods, technique in presenting statistics, the principal province of governmental statistics, etc. Thoroughgoing courses are offered in national economy with special application to the protection of properties and the development of new industrial opportunities. Correct practices and efficiency in government are likewise taught, as are the cultivation of prosperity in the different communities, and the [illegible]

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* Abstracts from a paper prepared for presentation at the annual meeting of the American Society of Mechanical Engineers.

[1] Wharton School of Finance and Commerce, University of Pennsylvania.

[2] "Vocational Education in Europe," Cooley, p. 11.

[3] "Government of European Cities," W. B. Munro, p. 178.

[4] German schools can be divided into the following two classes: (a) State institutions: (1) Those which are supported entirely by the State, and (2) those for which private corporations furnish a share of the cost; and (b) local community institutions, either pure community institutions or those to which either the State or local organizations contribute. There is a third class of institution, supported by associations and unions, which is not carried on for gain, but which requires considerable financial assistance from both the State and the city.

[5] The higher of these requires greater academic preparation and a longer course of study. Into the second will be admitted those without a complete secondary education but who have, at least, one year of practical training. The Hohere Maschinenbauschule is a real secondary technical school, the condition for admission being the completion of the six years' course in the academic secondary school, together with practical work in shop or factory for a period of two to three years.

tional programme for industrial supremacy. In the course germain to pure water for the city are given complete geological data. In short, the courses include minute, reliable, thoroughgoing investigations into the legal, social, economic, political, industrial and even geological ramifications of the municipal official's duties and responsibilities.

Quite in contrast to the Düsseldorf academy, which trains primarily the higher officials, is the Seminary for Public Officials at Aschersleben which offers a one year course preparing primarily for the one year probationary service by the middle and lower classes of public employes, and for promotion from one grade of service to a higher grade of service. The duration of the course is one year. The institution is administered by the magistrat of the city of Aschersleben. The courses offered include jurisprudence, administrative law, the science of taxation, political economy, social administration, the administrative courts, the budget, the treasury, accounting, bookkeeping, stenography, typewriting, arithmetic and German. The student is drilled so that he can hunt up and understand the decisions of the civil and administrative courts. The instructors are employed teachers and the public officials of the city of Aschersleben.

The need for further specialized training in America is to be measured by the extent to which existing educational institutions are meeting the rapidly rising demand for well-trained public officials who can look to permanency in the public service. The rapid adoption of commission government so that to-day it is applied in 806 cities with a population of 7,881,967, the adoption of the city manager plan of city government in 12 cities with a population of 229,062, the rise in the demand for sanitary experts, for engineering experts, for experts in marketing, in pure foods, in accounting, in taxation questions, and in the other fields of expert service in city, state and national life, the increase in the municipal ownership of public utilities, all these mean a rapid increase in the actual number of experts in the public service which in turn must mean greater permanency and better training for the public service.

The universities of our country are already doing a splendid work in providing for the public service. A large number of state scientific bureaus are located at the universities, such as public health laboratories at the Universities of Wisconsin and North Dakota, experiment stations in agronomy and animal husbandry, dairy husbandry, horticulture and botany, such as in the University of Illinois, experiment stations in engineering, such as in the University of Missouri, and testing bureaus, such as those at the University of Cincinnati. In the universities of Wisconsin, Oregon, Texas, Washington, California, Harvard and Cincinnati are legislative reference bureaus, which collect and compile information on matters pertaining to municipal legislation, public works, finance, sanitation, education, bibliographies, and statute-making and interpretation. Through the activities of the Committee on Practical Training appointed by the American Economic and Political Science Associations, our universities are beginning to make an extended use of the agencies for practical training available on every hand, such as the practical work by graduate and well-equipped undergraduate students in tax, railroad and industrial commissions, investigating boards, state boards of public affairs, city departments, boards of health, finance commissions, bureaus of municipal research and the different federal agencies in Washington. These laboratories are being and can be made, to an increasing extent, of as definite value to the students in politics, economics and sociology as the splendidly equipped scientific laboratories in the university buildings. All of the various universites now offer courses in constitutional law, in municipal government and allied subjects. University faculties are being called on extensively for practical work.

The University of Texas, with a large number of small cities round about, though with no large municipal laboratories at hand, such as are available in the largest cites, is planning for a department in municipal administration. New York University has a division of public affairs organized in 1912. The plans for this division include a course for graduate students which will give them an opportunity to conduct original research in problems of municipal government under the direction, not only of the faculty of the division, but also of the faculty of instruction and of permanent members of the administration of the city of New York. Moreover, tentative plans are under way for a system of administrative work for graduate students. This plan involves the assignment of two or more students to the same position, at which they will work in turn. Each will thus have time for college and class work, and at the same time will have an opportunity to get actual experience in public administration. There are, of course, only a limited number of positions in the city departments that can be handled in this way.

The University of Pittsburgh is making a special effort to be of service to the commonwealth and to the community, especially in its School of Economics which provides, through its departments of government and citizenship, an intimate understanding of the rights, duties and responsibilities of citizenship and of the functions and activities of government, municipal, state and federal. Students get special training for public service in commissions and administrative bureaus of various types, and in such semi-public organizations as trade and publicity organizations, bureaus of municipal and social research, and other civic and commercial bodies. In the University of Pennsylvania, students in certain courses, such as the course in municipal government, have been and are being assigned definite practical problems to be worked out through the various public bureaus, departments and public officials in the city. The University of Utah undertakes to disseminate through printed bulletins information that will be of service to the state.* The University of Cincinnati is a purely municipal institution which is relating itself in every way possible to the actual problems of the community and of the state. Thus in the department of chemistry of the engineering college is the bureau of city tests which analyzes, examines and estimates the value of all materials submitted by the municipal engineer or the purchasing agent of the city. The department of social science coöperates in social service with public institutions, such as the juvenile court, in investigations, service, etc. The department of psychology has been conducting some interesting work throughout the years past in regard to backward and deficient children in the schools. In this way its work is linked definitely with public school work. The professor in charge of the department of political science is also in charge of the municipal reference bureau at the city hall, which collects information, makes investigations and reports for the city. The college of medicine coöperates with the city hospital, contagious wards, the various clinics, etc. The engineering college coöperates with the city engineering, waterworks, street, sewer and bridge departments, in coöperative teaching, testing, reports and research work. The college of commerce coöperates with the banks of Cincinnati, though their committee, in collecting statistics and reports. In addition to this there is definite service by the individual professors. Students of such an institution necessarily get both the atmosphere and the positive knowledge of great value in their later service for the public. Space forbids the enumeration of other work in other institutions. Our colleges and universities are thus doing much toward practical training for the public service.

Thinking Animals[1]

About ten years ago it became known that "Clever Hans," an Arab stallion owned by a Herr von Osten in Berlin, was able to answer arithmetical and other questions, tapping out the reply with his fore-foot. Notoriety led to heated controversy, and the appointment of committees to investigate. The second of these, under Prof. Stumpf, resulted in Pfungst's book explaining everything in terms of signals consisting in slight movements made unconsciously by some person present knowing the answer. This seemed to have solved the problem finally until the appearance of Krall's book in 1912. The author, a wealthy jeweler of Elberfeld and friend of von Osten, had after the latter's death continued to experiment, obtaining results which, he claimed, refuted Pfungst's explanation. This claim found support in a report signed by the zoologists, Kraemer, Sarasin, and Ziegler, asserting that signaling was excluded since correct answers were given even when none of the human participants was visible to the animal. The opinions expressed on Krall's book vary from that of Prof. Dexler—"a shameful blot on German literature," to that of Prof. Ostwald, who foresees that it will "as clearly mark the beginning of a new chapter in the doctrine of man's place in nature as Darwin's chief work did in its day."

As to the problem itself, a definite solution could result only from a free and impartial testing of the animals; as it is one can only indicate probabilities. Intentional deceit is almost certainly too simple an explanation, and is in any case inadequate. On the other hand, the probability of obtaining correct answers by chance has been underestimated in view of the number of unsuccessful attempts and the greater frequency with which certain numbers occur. Very much must be allowed for this and other weaknesses of testimony, the demonstration of which has been one of the successes of applied psychology, but which, as every newspaper now shows, are seldom given weight in practice. They particularly affect some at least of the would-be crucial tests. Nevertheless much remains, of which the following main explanations have been offered.

The answers are evidence of mathematical intelligence. This, although a highly developed "number-sense" has been found in persons of low general ability, and even in the feeble-minded, conflicts with all that we know from other sources about the animal mind. Detailed scrutiny of Krall's account of his teaching shows that the problem often *could* not have been understood from his exposition. Again, the correcting of a single false figure is done quickly and certainly, as might be expected if signals were being given, since these would be facilitated by concentration of the signaler's attention; if the errors are mistakes of calculation it is odd. Finally, the inability of the animals to prove their understanding by action, compared with their eloquence in the language of taps, is extremely suspicious.

The answers are due to memory. The horse's memory is, no doubt, excellent for some things, and the theory has advantages, but also serious difficulties. To associate eight taps with one symbol and nine with another, the horse must be able to distinguish the two series. But it seems probable that animals cannot distinguish numbers beyond four or five. Rothe trained his dog to come only at the fifth whistle—but this only if the whistles were at regular intervals: his horse would take four lumps of sugar in preference to three, but confused four and five. Again, the horse's eye, while very sensitive to movement, is probably unsuited to the clear perception of complex visual forms such as written numbers, and, as a matter of fact, the animals seem to attend to the questioner more than to the blackboard. Finally, the mistakes in cube root, etc., questions strongly suggest the use of tips.

The animals are responding to unconscious signals. Krall claims to have refuted this by "ignorant" experiments, but these are relatively few and seem to have some weak spot. Thus Mackenzie reports that Rolf, the Mannheim dog, described a picture on a card held so that the holder could not see it; unfortunately, the picture was a red and blue cross, and there is reason to think that dogs are nearly color-blind. Nevertheless, the fair number of "peep-hole" experiments and the case of the blind horse, Berto, seem to stamp as inadequate Pfungst's theory of *visually* perceived movements. Yet no other mode of signal seems sufficient for all cases, while Hacker did actually get answers by moving his foot. Again, it is unlikely that the many individuals who have obtained answers should all make precisely the same unconscious movements. These difficulties disappear if we suppose the animals not to be blindly reacting to one specific stimulus, but to be interpreting more or less intelligently a general type of unconscious emotional ideo-motor expression—movement, variation of respiration, etc.—possibly always complex and varying with the individual and occasion. Both horses and dogs are notoriously sensitive to shades of emotional expression, and recent work by the Pawlow school indicates that dogs can hear sounds so faint as the beating of the heart. It is true, any theory of unconscious signalling presents difficulties. Units, tens, etc. are tapped with different feet; the spelling of verbal answers is phonetic, and *spontaneous* utterances are recorded, including a letter dictated by Rolf! Can the subconscious be credited with so much? The solution, if it ever comes, can scarcely fail to illuminate, if not the animal mind, at least that of man.—From *Nature*.

A Military Wireless Outfit

Wireless communication is destined to play an important part in warfare, and undoubtedly is doing so to-day, although comparatively little is heard of it so far. In this country the Signal Corps of the Army has recently acquired an unusually complete portable wireless outfit, which is believed to be the most powerful of its kind. The apparatus is mounted on a motorcar chassis and can be set up complete and in operating condition in as short a time as twelve minutes. Under favorable conditions, the apparatus has a sending radius of up to 800 miles. Messages from points 2,500 miles distant have been received. The generator which furnishes the current is driven by the same motor that propels the vehicle. Antenna of the umbrella type are used, the mast, which is in nine sections, being 85 feet in height.

* Some of these bulletins recently issued include discussion of the following subjects: Tests of brick; the construction and maintenance of earth roads; the economical design of reinforced concrete; measurement of flowing streams.

[1] (1) "Das Pferd des Herrn v. Osten (Der kluge Hans)." By O. Pfungst. (Leipzig: J. A. Barth, 1907).
(2) "Denkende Tiere." By K. Krall. (Leipzig: W. Engelmann, 1912).
(3) "Ueber den derzeitigen Stand des Krallismus." By Prof. H. Dexler. Reprint from *Lotos*. Prague, vol. lxii., 1914.
(4) "Gibt es denkende Tiere?" By Dr. S. v. Maday. Pp. x+451. (Leipzig: W. Engelmann, 1914).
(5) "Das Problem der Elberfelder Pferde und die Telepathie." By Prof. H. v. Buttel-Reepen. *Naturwissenschaftliche Wochenschrift*, 1914, No. 13.
(6) "Meine Erfahrungen mit den 'denkenden' Pferden." By Prof. H. v. Buttel-Reepen. *Naturwissenschaftliche Wochenschrift*, 1914, No. 16.
(7) "Zur Kritik der Leistungen der 'Elberfelder denkenden Pferde.'" By Prof. C. Schröder. *Naturwissenschaftliche Wochenschrift*, 1914, Nos. 21, 22.

A German field outfit for X-ray treatment.

X-Ray Work in War

Developments in Practical Applications as Now Used in the Field and in Hospitals

By the Berlin Correspondent of the Scientific American

THOUGH X-ray work has, even in normal times, become so valuable an aid to the medical practitioner that no up-to-date hospital can do without it, it is even more useful and necessary in warfare. Whenever, for instance, the shape and position of a projectile in the body of a patient are to be ascertained, Roentgen photography will quickly give all the desired information; if injured bones, and especially the splintering so frequent with bone fractures (shot fractures), are to be examined, it again proves the one safe guide. Roentgen photographs are nearly always welcome if the perforation made by a bullet has such a direction as to suggest the hypothesis of a bone lesion. The photographic plate in many cases shows the lesion to be much more serious than would otherwise have been supposed. In connection with the further checking of the treatment—in ascertaining, e. g., whether displacements of the bone ends have been adjusted by the dressing, repeated X-ray examination is of the highest importance.

It is true that X-ray work in its primitive form would have been of little use on the theater of war; but so many improvements have been introduced of late years, the technicalities have been so highly simplified, that even the ordinary practitioner will find no difficulty now in installing an X-ray outfit. Transportable apparatus allows the Roentgen ray to be readily employed everywhere in the field, even in temporary infirmaries. A particularly valuable feature is that patients submitted to a Roentgen treatment will suffer no pain or discomfort.

X-ray of a wound in foot caused by rifle bullet.

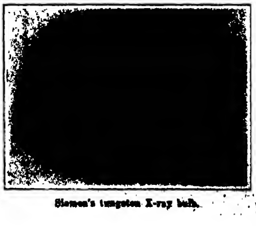
The apparatus serving to generate the rays may be of the most different types. They either consist mainly of an induction coil and interrupter—the active rays being produced by a rapid succession of alternate current impulses—or of a rectifier converting an alternate current into pulsating direct current, that is, a rapid succession of high-tension current impulses of constant direction. The latter type of apparatus is not only more simple to operate, which is especially valuable in warfare, but generally more effective, allowing snapshots to be taken in fractions of a second.

In the military hospital founded by Messrs. Siemens and Halske, in conjunction with the Siemens-Schuckert Works, the German Red Cross and the military authorities, there has, for instance, been installed an X-ray outfit allowing instantaneous views with exposures of only 1/100 second to be taken. This hospital, moreover, shows many other striking features, and may be considered representative of the best German practice in military surgery. It is housed in the administration building at Siemensstadt, near Berlin, and comprises in the four stories of its northern wing, four hundred beds in seven large halls and eighteen private rooms. An operation room appointed in accordance with the best modern practice enables even the most extensive surgical operations to be performed, mainly with the aid of X-ray pictures previously taken. By the courtesy of the managers, we are able to reproduce some such views derived from the hospital archives, which will be found most instructive. In another hall there have been installed all sorts of apparatus for electro-medical therapy.

Special transportable Roentgen outfits have been perfected for army hospitals installed at halting places, which generally remain stationary for some time. Beside the X-ray generator, these comprise a current generator, mostly a gasoline dynamo, so as to be independent of any electric installation. While these outfits do not lend themselves to taking instantaneous views, they allow even difficult X-ray pictures to be made with a few seconds exposure in conjunction with a reinforcing screen. The various parts of this outfit are contained in cases carried on automobile trucks, which, as long as the hospital remains at a given place, can be utilized for the transport of wounded soldiers. Special type of X-ray outfits have been developed for ship hospitals and hospital ships.

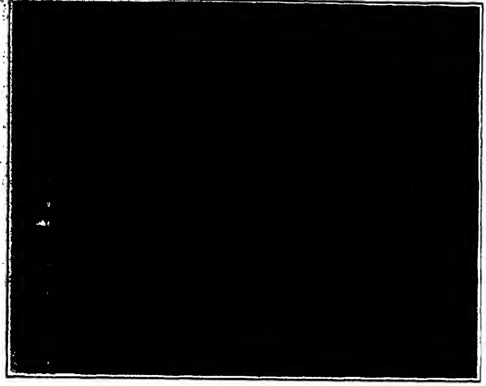
So large a number of pieces of electro-medical apparatus have been lately adopted that they cannot possibly be left out of account in a discussion of X-ray apparatus, the more so as they are directly or indirectly the outcome of the latter, and serve as efficient auxiliaries in Roentgen practice. Foremost among these should be mentioned the diathermic apparatus which by the application of high-frequency currents produces some sort of internal heating of the body. Diathermics is used with advantage in the treatment of neuralgic, rheumatic and gouty complaints; it is most valuable in the after-treatment of bone lesions, and its anesthetic effects are remarkable.

Electric temperature measurements are used in a rather unusual way at the Siemensstadt military hospital. The same as temperatures are determined and checked electrically from a central station in large heating and ventilating plants, the fever temperatures of



Siemen's tungsten X-ray bulb.

Triple fracture produced by a [illegible].



Recording fever temperature of a patient during a test of the effect of a sudatory.

patients are here recorded electrically and signaled to a central post. This, of course, affords a great advantage over the usual method of determining the temperature of the patients two or three time a day; in fact, the clear record of the course of temperatures thus obtained not only assists more efficiently in making a diagnosis, but affords some useful data in gaging the effect of medicaments or therapeutical methods.

Apart from the Roentgen apparatus proper, we should mention the accessories without which no sharp views could be taken. The same as in ordinary photography, a stop is placed in front of the objective, to keep off any lateral beams of light and thus to improve the definition of the picture, it is a good plan in X-ray work to screen off any secondary rays which are bound to impair the quality of the picture. The "compression" stop devised by Prof. Albers-Schönberg allows any part of the human skeleton to be reproduced with the utmost accuracy. Another type is Dr. Bucky's "beehive" stop, which intercepts any secondary rays produced inside the body before these are allowed to strike the projection screen or photographic plate.

For radioscopic and radiophotographic work on standing, sitting, or lying patients there have been devised quite a number of folding stands which will keep the body straight, in addition to avoiding displacements and insuring an accurate adjustment of the body.

The X-ray bulb itself, of course, is of the highest importance. Each military hospital ought to be equipped with quite a number of bulbs adapted for various purposes, part for radioscopy and part for X-ray photography. According to the special purpose each bulb is intended to serve, the vacuum must be more or less perfect; the higher the vacuum, the "harder" or more penetrating will the X-rays be, and *vice versa*.

A minor, though useful, accessory are the sand bags, which allow the patient to be installed most comfortably in any position.

The ascertaining of foreign bodies (projectiles) in the patient's body is generally limited to the upper extremities, neck, thorax, and to the lower extremities from the knees downward, as well as the skull. In order to mark certain points for subsequent treatment, small lead labels are glued to the skin, or the places in question are spotted with a blue pencil, ink, or tincture of iodine. In order accurately to ascertain the positions of a projectile in the body, two views—in planes vertical to one another—are, of course, required. A safe diagnosis for bone fracture can hardly be made on the strength of radioscopy, X-ray photography being generally indispensable in this connection. For checking the fracture in the plaster dressing, as well as for the diagnosis of sprains, radioscopy, on the other hand, mostly affords sufficient data to allow a safe conclusion to be arrived at.

Schmidt's universal X-ray stand.

Another point to be mentioned is that parts generally invisible (e. g., in examining the stomach and intestines) can be made visible by administering to the patient what is called a "contrast" meal, comprising some heavy metal salts, such as bismuth, impervious to X-rays.

Portable military X-ray outfit.

Wireless Telephony*

During the early part of March Mr. Marconi joined one of the Italian war vessels at Augusta attached to the squadron commanded by H.R.H. the Duke of the Abruzzi, and for several days he carried on experiments in wireless telephony with most satisfying results. During the first day radio-telegraphic communications were received from Rome over a distance of 366 miles, from Vienna over a distance of 600 miles, and from Clifden, in Ireland, 1,750 miles away. These communications were made during the day, and new high resonance receivers with photographic register repeaters were employed with excellent results. Experiments in wireless telephony were carried out on the following day between several vessels lying at anchor at a distance of one kilometer with great success. The wireless telephone experiments were continued on the third day, this time between two warships on the high seas, and the reception was consistently perfect over a distance of 30 kilometers. On the fourth and last days successful telephone experiments were again carried out, communications taking place with very limited energy between vessels on the high seas, 70 kilometers (45 miles) apart. On the last day radio-telephonic communication was constantly maintained for 12 hours, and the continuous working of the apparatus did not cause the slightest inconvenience. The apparatus employed in the experiments is of a new and simple type, and it was Mr. Marconi's desire that it should first be used on the warships of the Italian Royal Navy.

A new transmitting apparatus for wireless telephony was invented by Herr L. Kuhn. The microphone current is passed through a winding on a soft iron core on which is wound a second coil connected with the antenna circuit. The self-induction of the latter coil varies according to the fluctuations in the microphone circuit, and the oscillations in the antenna circuit, therefore, also vary in frequency accordingly. By this means it is stated than an oscillation energy of 8 kilowatts in the antenna circuit has been sufficiently influenced by a microphone energy of only 8.7 watts to effect a proper transmission of speech.

*The Engineer.

Effect of the War Upon Crime

The Basle *Nachrichten* publishes a summary of the offenses against the Swiss penal code, just before and since the outbreak of the war, concerning which complaints were made to the police authorities. While during July of the present year 269 complaints were made, the number reported for August is only 152, for September 177, and for October 158.

The statistics for 1913 give the following totals: July, 348 complaints; August, 314; September, 308; October, 301. At the close of July, 1914, the number of cases tried by the public prosecutor was about 140 more than for the same period of the previous year, while an inspection of the statistics up to the end of October shows a decrease, there being about 130 trials less than for the year 1913; that is, there was a falling off of about 270 cases in three months.

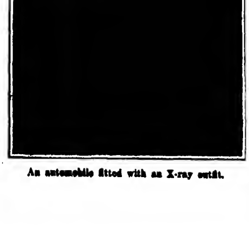
The German journal *Umschau*, in discussing these figures which it quotes, says that one important reason for this striking decline in the perpetration of crimes is that the floating population, from which a large percentage of the lawbreakers is drawn, has been largely reduced since the beginning of the war by removals, summons to the armies, expulsions, etc. The mobilization of the Swiss army has also exercised a favorable influence upon criminal statistics.

The fixing of an hour for the closing of the saloons led to an abatement in assaults, crimes against property, threats, and acts of insubordination. Most interesting of all are the figures concerning the complaints of assaults.

In 1914 the complaints as to premeditated bodily assaults run as follows: July, 28; August, 13; September, 18; October, 17. In 1913 the figures were: July, 37; August, 31; September, 29; October, 25.

In the months of August, September, and October, 1913, there were 9 complaints in regard to acts of insubordination, while during the same period of the year 1914 only a single case was brought before the division for criminal investigation.

In a few cases of brawls the quarrels arose from the fact that the sympathies of the population of Switzerland are divided between the countries at war.



An automobile fitted with an X-ray outfit.

Chemistry of Flaming Arc Carbons*

Their Development and Operation

By Dr. William C. Moore

In an arc struck between two carbon electrodes, very nearly all the light comes from the incandescent electrode tips. In a direct-current arc, the positive crater is larger, and possibly at a higher temperature than the negative crater, and it is this positive crater which is the source of most of the light. Since the crater is merely an incandescent solid, it affords a continuous spectrum. Colorimetric experiments recently made by L. A. Jones and reported by him at the Cleveland meeting of the Illuminating Engineering Society, September, 1914, show that this incandescent crater has about 67 per cent of the daylight value of noonday sunlight. When volt-ampere readings are taken with such an arc it is found that if the arc is strengthened the voltage rises and the amperage falls, and eventually the arc goes out.

If we use as one of our electrodes a carbon rod which has been hollowed out into a cup, and place in the cup some potassium chloride, and again strike the arc, we find that the volt-ampere characteristics are changed and that at the same amperage a much longer arc can be drawn. Cassellmann in 1844[1] seems to have been the first to have noticed this fact. As we see, an arc fed with potassium chloride gives very little light; in fact, probably less than the pure carbon arc, as the positive crater is not so bright. This arc has a distinctive color, and, of course, would show, besides the carbon arc lines, the potassium lines in the spectroscope. Bunsen[2] in 1844 seems to have been the first to notice that different materials give different spectra in the arc.

If, instead of potassium chloride, we place a small amount of calcium fluoride in the hollow carbon cup, which, in this as in the previous case, is in the lower positive carbon, we find that the arc length for a given current and voltage is much shorter than for potassium chloride, and longer than for a pure carbon arc; moreover, the arc is intensely luminous, though rather unsteady and liable to go out. On placing a mixture of potassium chloride and calcium fluoride in the arc, we get the combined advantages of a *long* arc, with more intense luminosity than is afforded by either the pure carbon arc or the potassium chloride arc alone. These simple facts form the starting point in the development of the modern flaming arc.

About 1899, Bremer, in Germany, brought out a flaming carbon, with calcium fluoride as the essential light-giving salt. The light afforded by such a carbon is a sensation yellow; the color is more aptly described, however, as "minus blue," as the spectrum of such an arc is very deficient in the blue.

From 1899 to the present the development of the flaming arc has been going on steadily and surely. It is interesting to note that the first record the National Carbon Company has of any work being done by them on the subject was when some ordinary cored carbons flamed and experiments were undertaken to prevent this phenomenon.

Although Bremer produced a carbon which could be burned vertically, for a number of years most of the commercial lamps were "inclined trim" lamps, taking long, cored carbons, which burned under open-arc conditions. A few years ago, however, there was developed a lamp for burning flame carbons in a vertical position, and for these lamps solid carbons have been developed. An interesting point is that the idea of solid carbons antedated the development of the lamps. These lamps generally operate in such a way that a limited supply of air reaches the arc; that is, under "inclosed-arc" conditions. These various types of lamps are doubtless familiar to the illuminating engineers present.

Modern flame carbons may be classified in several ways. From the standpoint of the mechanical structure of the finished carbon, we have cored carbons and solid carbons. From the standpoint of the color of the light emitted by the carbons, we have a major division in which are included yellow flame carbons and white flame carbons, and a minor division including red, green and blue flame carbons, red and green being but little used except for advertising purposes, and blue being used as a source of blue and ultra-violet light for medicinal purposes.

In the major division, calcium fluoride is the chief constituent of yellow flamers, and rare earth compounds the chief constituents of white flamers.

A brief description of the method of manufacture of flame carbons may not be out of place. The first step, of course, is the careful weighing out of the requisite amount of the carbon base, and the proper flame materials for making a "mix." Most of these mixes are rather complex. After weighing, the ingredients are very thoroughly incorporated together and with an appropriate binder—generally tar or pitch or a mixture of these. The "mix" is then forced by means of an hydraulic press into long rods, which after cooling are cut into the proper lengths. These green carbons are then carefully baked in gas-fired furnaces and the temperature gradually raised according to a definite schedule, the final temperature attained being determined by a number of factors, such as the liability of some of the constituents to violatilise, or to react with each other and the carbon.

After cooling in the furnace, the carbons are unpacked, sorted, cleaned and gaged, the latter process consisting in determining the diameter, as but small variations in diameter are permissible; the carbons must also be quite straight. Some solid carbons are electroplated with copper on the holder end to make a better contact between the lamp holder and the carbon. After plating, they are dried and made ready for shipment.

It is, of course, necessary to keep all flame carbons dry, as water may cause reactions between some of the flame materials, or may set up on a carbon-copper cell with some of the soluble or partially soluble salts as electrolytes and thereby destroy the copper coating. Water has another detrimental effect as shown by W. R. Mott,[3] namely to react with the carbon at high temperatures, forming carbon monoxide and hydrogen; the latter may not only accumulate in the lamp housing and cause the lamp to explode when started again, but rapidly conducts heat away from the burning arc and lowers its efficiency.

The manufacture of cored carbons is quite similar to that of solid, except that the carbon base is different, and in forcing the die contains a pin which makes the carbons hollow. After baking, sorting and gaging this core hole is filled with a mixture of a carbon base and the flame materials with an appropriate binder, and the carbons are then dried. As cored carbons are usually very long and of small diameter, a zinc wire is inserted into a small hole parallel to the core hole. This wire increases the conductivity of the carbon. In order to make a good contact with the carbon and the holder, the carbons are "silver tipped"—that is, first copper plated, then dipped into solder, which solders the zinc protruding from the holder end to the carbon. Such a connection is a permanent one, and is far superior to the scheme of simply bending the zinc over at the end of the carbon as the zinc becomes brittle when the core is dried and is liable to break off.

We now come to the question of desirable operating characteristics for a flame arc carbon. First of all, such a carbon should be reliable. It has been pointed out by Steinmetz[4] that after high efficiency is attained, we can afford to sacrifice some of the efficiency for reliability and other desirable factors. As will be shown below, the flame arc is already of high efficiency, hence we place reliability as our first desirable characteristic.

We may consider reliability under the four heads:

1. Constancy of distribution.
2. Constancy of light flux.
3. Constancy of color.
4. Ability to start with cold points after the carbons have been in use.

The length of the arc has a great deal to do with the amount and distribution of light. As the arc lengthens, the voltage increases; it is stated by Hechler[5] that there is a maximum definite voltage for maximum efficiency, that is, some definite arc length gives the most light.

The part that chemistry has had in increasing the reliability may be briefly indicated. It is readily seen that a flame arc which burns brightly part of the time and dimly part of the time can hardly be said to have 100 per cent reliability if all the other factors are high. It may happen that all the flame material is evaporated from a given spot on the surface of the carbon, thereby causing a pure carbon arc for a short time. Such changes, however, are now rare, as a great deal of constructive chemical work has practically obviated this feature. As another factor affecting the reliability of operation of flame arc lamps is the formation of slag on the points or on the lamp mechanism, it is readily seen that the proper proportion of the flame constituents and the right kind of addition agents for preventing such slags are of great importance, and here again we find that extended chemical research has resulted in the development of carbons in which this source of trouble has been largely overcome.

It has been mentioned that the flame arc is of high efficiency. The following figures are from some regular routine tests made in the laboratory:

Lamp	Current	Kind of Carbon	M.H. C.P.	Arc Watts	Watts per Candle
Excello	A.C.	Cored—yellow	1,230	363	.30—
Excello	A.C.	Cored—white	843	360	.43—
Excello	D.C.	Cored—yellow	1,462	445	.30—
Excello	D.C.	Cored—white	875	450	.51—
G. E. Type W.	A.C.	Solid—yellow	700	397	.56—
G. E. Type W.	A.C.	Solid—white	808	394	.49—
G. E. Lynn.	D.C.	Solid—yellow	1,181	409	.35—
G. E. Lynn.	D.C.	Solid—white	930	421	.45—

The slightly lower efficiencies with the solid carbons are due to the fact that they are used in inclosed lamps, to which the air has only limited access, and so in these lamps there is less oxidation of the carbon and the flame material.

Some work by Henry P. Gage[6] at Cornell University on the efficiency of the arc stream proper may be cited here. This investigator found that with cored yellow-flame carbons the energy radiated as light from the arc stream was 30 per cent of the total energy radiated by it; with the arc stream, from cored white flame carbons 27.5 per cent of the energy radiated by the arc stream was light energy. The entire yellow arc showed six candles per watt radiated, while the entire white arc showed three candles per watt actually radiated.

These values are for the spectral region between 3,800 and 6,800 Angström units, and for alternating current at 13.5 ampers. The following data may be presented as to the life of flame carbons:

	Life in Hours. A. C.	Life in Hours. D. C.
Cored, yellow	12.0	12.50
Cored, white	11.08	11.25
Solid, yellow	115.08	125.0
Solid, white	120.0	96.42

These figures show why the inclosed flame arc lamp is more popular than the old "inclined trim" lamp, using cored carbons.

Having indicated at a number of points the important part chemistry has played in the development of the modern flame carbon, let us now take up in greater detail some of the chemical aspects.

In the first place, the selection of the proper materials for the manufacture of flame carbons is to a very large degree dependent on the chemical properties of those materials. When we consider the carbon base, we find that the chemical behavior, as well as the physical behavior of the various so-called forms of carbon, differs with the type of carbon employed. To use an extreme case as an illustration, we know that the chemical properties of graphite differ greatly from those of lampblack. There are likewise similar differences between charcoal and lampblack, petroleum coke and retort coke. This, in part, accounts for a different carbon base being used for solid and for cored carbons.

To a greater degree than the proper selection of the right carbon base the selection of the right sort of flame material and the right sort of addition agents with this flame material has been a chemical problem. This is illustrated by the fact that to-day we know no better material than calcium fluoride for the main constituent of yellow flame carbons. I do not think I will exaggerate the matter in the least when I say that compounds of every compound-forming element have been proposed as proper substances to incorporate into flame carbons—some of them in all sorts of possible and impossible combinations.

Having selected the right materials, the right amount of each is our next chemical problem. That the candle power depends upon the amount of flame material is well known; more exact information on this subject, however, may be had from the following table, which is from some work done in our research laboratory by

* Paper read before a joint meeting of the New York Section of the Electro-chemical Society; the American Illuminating Engineering Society and the American Gas Institute.

[1] *Pogg. Ann.* 63, 576 (1844).

[2] Berzelius, Jahresbericht über die Fortschritte der Chemie und Mineral., 25, 20 (1846).

[3] Mott, *Electrical World*, December 13th, 1913, *p.* 1,236.

[4] Gen. *Electric Review* 17, 130 (1914).

[5] Abstract in *Electrician* (London), 69, 666 (1912).

[6] *Phys. Rev.* 33, 111 (1911).

Mr. William R. Mott, using cored carbons in an Excello direct current lamp:

Parts of calcium fluoride by weight.	3	2	1	0
Parts of other salt by weight.......	0	1	2	3
Mean spherical candle-power.......	927	1,058	765	574

As is seen, there is a maximum per cent of each of the constituents which will give the most light. This is true with nearly every substance which may be added to the calcium fluoride, and when we consider that flames contain three or more substances in addition to the main constituent, it is readily seen that the nice adjustment of all these substances to each other presents some very interesting problems. It also explains why so much of our knowledge has been obtained in an empirical way. It is, of course, understood that the maxima for different addition agents do not coincide.

The chemical control of the impurities present in the raw materials is of great importance. Silica, ferric oxide and alumina, as is well known, are common impurities in calcium fluoride, and it so happens that too much of these impurities will make a poor burning carbon. Silica is especially undesirable, as calcium silicate is very non-volatile and so is a frequent cause of slag formation. The analytical difficulties in determinations of fluorine, silica and rare earths in the presence of each other and of carbon are very great.

The unbaked carbon is a poor conductor of electricity. It is also rather friable. In the baking, the binder is coked and the carbon is rendered homogeneous and conducting. This coking of the binder is the chief chemical change in the manufacture of the carbon.

We now have to consider what chemical changes may occur during the burning of a flame carbon, and how these may affect the light emitted from the flaming arc. There are three possible sources of light in the flaming arc: electro-luminescence, thermo-luminescence, and chemiluminescence. We do not know to what extent these three factors affect the light radiation in any one case. We do know, however, that in general there are two types of flaming arcs, (1) those in which the outer sheath seems to be intensely luminous, (2) those in which the core of the arc seems to be more luminous than the sheath. With very few exceptions arcs of the latter type give light of the shorter wave lengths. We have here an arc into which calcium fluoride is introduced, it is a representative of the first type; here is an arc into which chromic oxide is introduced, it is of the latter type. King has recently reported[1] that in a tube furnace almost all of the spectral lines seen in the arc spectrum of titanium appear, so that it would appear that in some cases a large proportion of the light from an arc is due to thermo-luminescence, though all possibility of chemical change was not precluded by these experiments.

Oldenberg[2] has made a spectro-heliographic study of various arcs, with some interesting results. For instance, he concludes that in the sodium arc, lines belonging to the principal series such as the "D lines" are due to chemical reactions between the vapor and the air. Band spectra seem to be of two types: those of the first type are due to collisions of atoms in the high temperature core of the arc. The cyanogen bands always seen in a carbon arc he ascribes to collisions between carbon and nitrogen atoms. Bands of the second type are found in the sheath of the arc; they are due to undecomposed molecules; the bands of the calcium fluoride spectrum are of this type. When we consider that the flaming arc is a miniature electric furnace; that Fremy[3] showed years ago that oxygen converts calcium fluoride into calcium oxide; that calcium oxide and carbon react to give calcium carbide and carbon monoxide, and that the other constituents of a flame carbon may react with calcium fluoride, with the carbon, with each other and the atmospheric gases, we see that it is possible for chemical changes to play an important part in the production of the light of the calcium fluoride arc. Each of the possible substances may play its part in this light emission.

In conclusion, I think we may safely say that the past progress made in the flaming arc art has been due to the co-operation of the chemist, the physicist, and the electrical engineer; the future progress will likewise be dependent upon their combined efforts.

It might not be out of place to point out that the behavior of any one substance in the arc is determined by the conditions surrounding that substance—it behaves according to definite chemical and physical laws; and that our knowledge of these laws for high temperatures is exceedingly meager. On the other hand, once these laws are learned, it will probably be easier to build lamps to suit the carbons rather than to make a carbon to fit any and every lamp. In the extension of our knowledge of these laws, chemistry and especially physical chemistry will play an important part.

[1] *Astrophysical Journal*, 39, 139 (1914)

[2] *Zeit. f. Wiss. Photog., Photophysik und Photo. Chem.*, 43, 133 (1913).

[3] *Ann. Chem. Phys.*, (3) 47, 17 (1856).

Uniformity in Dosage of Radium Emanation*

The Various Forms Employed and Methods of Preparation

By William Jay Schieffelin, Ph.D.

Radium emanation is assuming importance as a therapeutic agent. The Council on Pharmacy of the American Medical Association has listed radium and its emanation among new and non-official remedies; an increasing number of physicians are using the emanation in their practice, and articles and advertisements on the subject are appearing in the medical journals. Since radium and its emanation are becoming recognized as belonging in the materia medica, their production and properties and the standardization of their preparations may be claimed to come within the scope of pharmacy.

Radium is prepared from carnotite (vanadate of uranium and potassium), uraninite or pitch-blende (uranium oxide), and samarskite (columbate and tantalate of uranium and yttrium). Radium has an atomic weight of 226, and resembles barium in its chemical properties.

In its characteristic property of radioactivity radium is sublimely superior to its environment, whether in its natural minerals or isolated from them, and in all of its chemical compounds it is constantly emitting alpha rays and emanation at a uniform rate, and there is no known way of influencing or halting this activity, which is not affected by the extremes of heat and cold, by pressure or the strongest reagents. This radioactivity shows the energy which results from the disintegration or transmutation of radium into elements of lower atomic weights.

A milligramme of radium expels 136 million separate alpha particles per second, which are made visible in a spinthariscope. The alpha rays emitted from one three thousand millionth of a grain of radium can be detected by the gold-leaf electroscope. The rays are given out uniformly in all directions in the form of continuous volleys of tiny projectiles traveling at a rate of 12,000 miles per second. Their range is nearly three inches in air and many yards in a vacuum. They are not penetrating, being absorbed by thin sheets of aluminium, paper or glass. Only a small fraction of the alpha particles is set free, unless the radium salt is spread out so as to present the largest possible surface.

The emanation is a gas, which, in turn, steadily disintegrates into alpha particles and radium *A*, from which in the same way come radium *B*, *C*, *D*, *E*, and *F* in succession. It is from these products, especially radium *C*, that the beta and gamma rays are given off. The beta rays are electrons of negative electricity, the same as the cathode rays, except that the velocity of the beta particles is much greater, approaching the velocity of light, 186,000 miles a second.

The gamma rays are not considered to be particles of matter, but are waves in the ether similar to the X-rays. They are far more penetrating than the alpha and beta rays, and used in the external application of radium in cancer, the others being easily excluded by thin metal filters.

The emanation has an atomic weight of 222, and a characteristic bright line spectrum. It belongs in the group of inert monatomic gases with helium and argon. It is not absorbed by any known re-agent and shows no power of chemical combination. The emanation is 100,000 times as active, weight for weight, as radium. Like other gases, it can be collected, confined and handled in ordinary glass containers. This is usually done only when it is mixed with enormously greater volumes of air or other gases. Like other gases, the radium emanation is somewhat soluble in water. It disintegrates at the rate of one-half in about four days, and since the radioactive products into which the emanation disintegrates decay at the rate of one half in a few minutes, it follows that the total radiation from the emanation and the subsequent disintegration products decreases at the same rate as the emanation, namely one half in about four days.

When water with emanation in solution is left in an open bottle the emanation diffuses out, and if the water is shaken up or otherwise disturbed the process of diffusion of the emanation is accelerated. From 10 to 30 per cent of the emanation in solution in water may be lost by pouring from one vessel to another.

The strength of radioactive water is usually expressed in mache units per liter. Radioactive water of 2,700 mache units contains per liter as much emanation as is emitted in thirty days by one microgramme of radium (1 mache unit equals 0.001 electrostatic units, one of which equals 3.33 by 10^{-10} amperes). The radioactivity of water is measured by a fontactoscope, which is an electroscope with a chamber for ionized air and a scale for measuring and timing the discharge. The instrument is standardized by first testing a solution of a known amount of radium chloride which has been sealed thirty days. Great care must be used in sampling the water.

Water is charged either by dissolving the soluble bromide or chloride of radium or by submerging the insoluble sulphate. The later is more economical, but the sulphate must be in a minute state of sub-division and must present the largest possible surface.

There are several ways of accomplishing this:

First—Precipitating the sulphate on asbestos and placing it in a porous cell.

Second—Mixing it with charcoal and forming into slabs.

Third—Mixing it with cement and forming balls.

Fourth—Mixing it with clay and firing it, forming terra cotta.

Most of these processes are protected by patents. The advantage of using an insoluble salt is that it can be employed repeatedly and its use continued indefinitely. The terra cotta rods can be used eighteen hundred years and still have half their radium content available.

Moreover, they avoid introducing into the organism a permanent radio-active body, as is done if a soluble salt is administered.

While a given amount of radium always emits a constant and uniform amount of emanation, the proportion given out by an insoluble salt depends upon its state of subdivision.

In the insoluble salts most of the emanation is occluded by the salt itself; in compact form the sulphate will only yield two and a half per cent, while if it is finely powdered and divided so that it presents a large surface, ten per cent can be obtained.

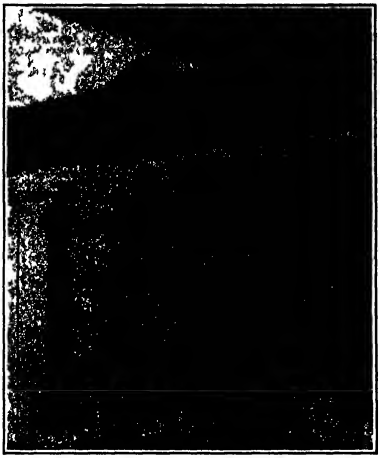
A uniform strength of emanation is obtained when the same amount of radium sulphate is held in the same state of subdivision, submerged in the same volume of water for the same length of time.

If it is desired to prepare doses of 100 mache units, and the sulphate can be held in such a state that ten per cent of its emanation is available (as is the case when distributed through porous terra cotta) it will be convenient to use an amount of radium which would yield 2,000 mache units and submerge for four days in tightly closed containers, when one half of ten per cent or 100 mache units will be obtained.

The stronger natural springs contain from one to two hundred mache units per liter, with which they are charged while flowing over radioactive minerals or passing through cavities where the emanation has collected. The reason why many mineral waters when drunk at the springs give therapeutic results unattainable when they are bottled and transported, is the speedy dissipation of the fugitive emanation, which is reduced to one half in four days unless there is a source for its renewal. The means of renewing the radioactivity of bottled waters, or of charging any water with emanation, are afforded by the above-mentioned devices, and the physician may prescribe a drinking cure which can be carried out with precision in the patient's home.

The chief effect of the radiations from radium and its disintegration products is to produce an ionization of the atoms of whatever substance the rays penetrate. Chemical effects follow as a secondary result of the ionization. Von Noorden and Falta say that "in contradistinction to all other forms of electro-therapy, we possess in the radioactive substances a means of carrying electrical energy into the depths of the body, and there subjecting the juices, protoplasm and nuclei of the cells to an immediate bombardment by explosions of electrical atoms. We may, therefore, designate this internal treatment with radioactive substances, internal electrotherapy."

* Read before the annual meeting of the American Pharmaceutical Association.



How steel darts are dropped from an aeroplane

Insert on the left shows a dart about half size on the right the box from which they are discharged

Aeroplane Darts and Fire Darts*

Even before the war began the French made many experiments in throwing missiles from aeroplanes. The best known of these projectiles are small bombs or hand grenades about as big as oranges which are launched from tubes or thrown by hand at large terrestrial objects, and which explode on impact. Experiments were made also with a large bomb or shell which was slung beneath the aeroplane and dropped by casting loose its suspending cords. Not many of these large bombs however can be carried by an aeroplane

A very different missile the short steel dart, has been frequently used by French aviators during the present war These darts are rods of pressed steel about as thick as a lead pencil Four grooves extending through two thirds of the length considerably diminish the sectional area and weight of that part of the dart and give the cross section of the tail the form of a four pointed star

Hence the dart always falls with its heavy cylindrical and sharply pointed head directed downward The darts are made in two lengths about four and six inches with corresponding weights of ½ and ¾ ounce They are thrown with the aid of a special device in bundles containing from thirty to fifty darts but they promptly separate so that they are dispersed over an area of 5 000 square feet on striking the ground when dropped from an elevation of about 1 500 meters or 5 000 feet This height of fall gives them a striking velocity of 200 meters (about 650 feet) per second approximately that of a rifle bullet, so that they are able to inflict severe wounds

The effectiveness of these darts cannot yet be conclusively judged In a case reported to me by eye witnesses a shower of darts fell upon four companies encamped in a small space One third of the darts found victims, and inflicted many severe and a few fatal injuries The conditions were especially favorable for the attacking aviator and this example should serve as a warning not to encamp several companies together In another case I found that the darts had only slightly wounded a few men One dart had struck a horse's rump inflicting a painful flesh wound but not disabling the animal

Another aeroplane missile is the fire dart devised especially for attacking and destroying airships. The experiments with fire darts that have been carried on at the Eiffel Tower and elsewhere in France since 1910 have resulted in the construction of a service type which will probably be employed in the present war This fire dart is 16 inches long 3.2 inches thick and 2 pounds in weight. It consists essentially of a tube containing one half pint of benzine and a stout steel needle In falling it is kept in a vertical position by the action of a little screw propeller at its upper end When it falls on an airship the point of the needle protruding from the lower end of the tube pierces the gas bag to which the tube is then held fast by six fish hooks The impact ignites an explosive mixture packed around the needle and the benzine and the gas of the airship are ignited in rapid succession I have not yet heard of the employment of these fire darts in the present war

* Translated from the report of a war correspondent of the *Kriegstechnische Zeitschrift*

A consideration of the formula $V = \sqrt{2gh}$ and remembering that in the metric system g is about 10 shows that an altitude of about [illegible]000 meters would be required to produce a velocity of 200 met sec even in vacuo A much greater height would be required to produce the same result in air.—Editor.

Philosophy and Technics*

We regard the triumphal progress of the natural sciences with justifiable pride An immense fund of knowledge has been accumulated problems that seemed hopeless have yielded to research and upon the progressive understanding of the harmony of nature has been reared the imposing edifice of modern technics the characteristic monument of our era Although many important questions are still unanswered and extensive fields of knowledge have been only discovered not explored yet a sort of stopping point seems to have been reached The recognition of this fact is manifested in the newly awakened interest in the history of science and in the endeavor to take stock of the results hitherto accomplished and to attain a clear idea of the real value of science

For the successes of science have not prevented the uplifting of voices warning against over-valuation of those successes. Skeptics have asked if the progress of chemistry and physics has brought us nearer to "the truth Have we made a single step toward the understanding of the essence of things? The number of these critics is increasing and the expression bankruptcy of science is heard Doubters have arisen in the ranks of science itself It was a physicist who defined science as economy of thought a means of arranging for convenient reference the impressions with which we are stormed by our environment.

Technology appears now to be undergoing a similar development To a superficial observer it shows splendid triumphs, the accomplishment of results unthought of a few decades ago In the words of Lamprecht it is no longer an embryo but a well-developed, beautiful and strong personality in the zenith of its power This maturity appears to be leading to introspection. We look away from the work in order to discover the true sense of technics, and this inquiry involves others, no less important, for which we have not hitherto had leisure. Whence comes technics and whither does it lead us? Does it mean nothing more than the application of scientific discoveries to the solution of prosaic problems of utility? Is its sense exhausted in its economic value in the satisfaction of the impulse toward self preservation, in the chase after wealth and economic power? Or is it based on some idea higher than the principle of utility? In other words, is there a philosophy of technics?

In the year 1877 Ernest Kapp published a book now almost forgotten, entitled Outlines of a Philosophy of Technics (*Grundlinien einer Philosophie der Technik*) The author who came from the camp of Hegel endeavored to explain from the anthropocentric viewpoint, the whole development of technics by unconscious projection of the human organism upon external things. In this theory the hand, arm and jaw are the prototypes of the earliest tools and utensils. In the hammer the arm is prolonged and the power of the fist increased the rigid forefinger with its sharp nail is imitated in the drill the teeth suggest the file and saw the hollowed hand is the pattern of the bowl The parts of the body especially the hand, project their dimensions and numerical relations also. The span, foot, ell, etc were the earliest units of measurement and the ten fingers gave us the decimal system of notation. Even the movements of the limbs are repeated in machines for levers pendulums, axles cords and hinges are found in the human body

Kapp's theory has been criticised by several writers. Eyth, one of the most philosophical of technicians, has objected that weaving fire-making and many other important technical arts cannot be explained by the projection of human organs F Reuleux has asserted in his valuable treatise on the theory of machinery that the most rapid progress in technics has been made where men have freed themselves from natural prototypes and tried to solve problems by their own means, often radically different from those of nature.

To these critics it may be replied that imitation does not necessarily mean the production of a perfect likeness Biology furnishes technics with elements which are employed in altered forms and combinations conditioned by the nature of materials For example it is not a valid objection to the theory of projection to show that continuous rotation about a fixed axis does not occur in the human body The movement of the arm in a circular arc about the shoulder joint contains the same element of motion that we find developed and perfected, in the swiftly turning wheel of a machine.

We must, therefore agree with Kapp that there is a remarkable similarity between mechanical tools and human organs It is another question whether we shall also agree with him in regarding both as expressions of a unperceived metaphysical principle Here the philosophy of technics becomes merged in the general problems of philosophy and agreement or disagreement with Kapp will be conditioned by the viewpoint of each individual philosopher

Metaphysical philosophy is not in great favor nowadays. Philosophy is continually becoming more practical. As natural philosophy it stands in intimate association with the natural sciences or it seeks a connection with psychology or it invades the field of ethics In like manner the philosophy of technics has become a philosophising about technics an introduction of psychological social-ethical and other problems into the field of thought of technics. These questions are discussed by Eberhard Zschimmer in a recently published book (*Die Philosophie der Technik*) which is symptomatic of the changes that have occurred in the meaning and the valuation of technics. Zschimmer sees in technics the organic part of a greater phenomenon" namely the development of civilization (*Kultur*) By extending the range of our senses and increasing our power over the forces and material of nature, technics assures to the human race the material freedom which it needs for the conscious, creative work of perfecting its development. Hence, the function of the technician is comparable with that of the artist, for each is devoted to the conscious realization of an impersonal idea As the idea of art is unfolded in the experience and enjoyment of the artist's creation, so the idea of technics is realised in the experience and enjoyment of the material freedom which the work of the technician gives to mankind.

Unhappily we are yet far distant from this ultimate goal of technics Certain economic dissonances and certain forms of work, specialization and mechanization are so conspicuous as the results of technical development that the ideal value of technics is difficult to recognize. But technics should not be held accountable for these unwholesome by products The object of a philosophy of technics is to prove that technics is something more than an arithmetical problem in national economy and that its true value is unquestionably to be found in the subordination of personal interests to higher ideals.

* Translated from Dr Guenther Bugge's article in *Prometheus*.

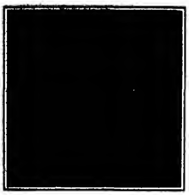


Fig. 1—House-flies, an instantaneous photograph made without a lens, exposure 1/90 seconds. Magnification 1 7

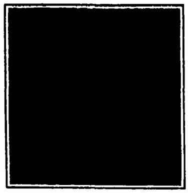


Fig 2—Vegetative growths of a form of bacteria from an analysis of water gelatine culture in a Petri tube Magnification 1 7

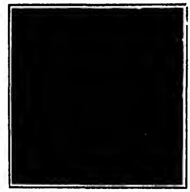


Fig 3—Daphnia and Cyclops swarming around a twig of Elodea Canadensis, exposure 1 90 seconds. Magnification 1 7

Instantaneous Photography Without Camera or Plate

An interesting note in the German journal *Prometheus* summarises the account given by Prof Dr P Lindner in *Mikrokosmos* of his experiments in instantaneous photography without camera or plate The negatives were produced on gas light paper by the use of parallel rays and the avoidance of all side lights The source of light was daylight or in photographing constantly moving living objects a direct current arc-lamp, the rays of which were made parallel by means of a concave lens. The objects were placed in narrow shallow glass dishes and the short exposure was obtained by passing a piece of pasteboard with a slit in it before the dishes

Ordinarily photographs without a camera are produced only by means of the Roentgen ray Undeterred by the unusualness of the operation Prof Lindner succeeded in obtaining his shadow like photographs in which the sharpness of the outline is as surprising as the simplicity of the method

Catalysis in the Gas Industry*

When the engineer appeals to the chemist for an explanation of certain reactions and is answered that they arise from "catalysis he is apt to hint that the reply masks a plea of ignorance. Frequently the suggestion is justified At the same time some catalytic processes are as well understood as the chemist under stands any reactions The term catalysis was introduced by Berzelius in 1837 but Kirchhoff Humphry Davy, Faraday and others had quite recognized the peculiar character of the reactions long before that That catalysis plays a great part in the gas industry might not at once be granted but a little reflection will show that catalysis must come in and Dr R Lessing certainly made out a good case for Catalysis in the Gas Industry when recently delivering the William Young Memorial Lecture before the North British Association of Gas Managers at Glasgow

The definition of catalysis for which Dr Lessing expressed preference was that given by Ostwald A catalytic agent is a material which affects the velocity of a chemical reaction without itself appearing in the final products.' The definition Dr Lessing pointed out, implied that the reaction is possible even in the absence of the catalyst, and that the catalyst does not appear in the final product, though it may and does probably form unstable intermediate products which are decomposed and re-formed This view is indeed the basis of one of the hypotheses offered for explaining the phenomena The other hypothesis suggests absorption or occlusion of the reacting substances on the surface and in the pores of the catalyst, the acceleration of the reaction then being due to the higher concentration of the reagents, which may be solid liquid or gaseous. As regards coal and gas, Dr Lessing remarked, there is scarcely a step in the course of the treatment which coal undergoes, from the mine to the burner or chimney flue, on which catalytic influences have not some bearing In 1882 Abel suggested that "coal-dust exerts a contact or catalytic action upon gas mixtures similar to that possessed by platinum ' There is a kernel of truth in that suggestion, though it does not cover the whole range of the phenomena of coal-dust explosions. The occlusion of methane, oxygen and other gases by the large surfaces of the carbon particles would facilitate not only explosive combustion, but also spontaneous combustion. The older view attributed spontaneous combustion and gob-fires chiefly to the presence of pyrites, modern chemistry inclines to the [illegible] that the constitution of the organic matter is often itself sufficient to render spontaneous combustion possible, and that the [illegible] act more as catalysts [illegible] at the primary cause. Dr. Lessing mentioned in this connection some recent work by K A Hofmann Schlumpelt and Ritter they found that even retort carbon and lamp-black can be oxidised at temperatures below the boilingpoint of water by dilute solutions of potassium chlorate when catalytically activated by osmium trioxide or by solutions of bleaching powder

If coal is subject to catalytic influences at ordinary temperatures at which it appears chemically inert, it stands to reason that these influences will exert them selves strongly at the high temperatures of carbonisation considering the complexity of the organic coal substance which always includes mineral matter All the primary products from coal suffer decomposition on coming in contact with the hot retort walls or hot coke If the walls themselves have such an effect the physical structure and the chemical composition of the retort walls may be expected to have an influence it would be of interest therefore to try glazed and unglazed retorts and retorts made of silica highly aluminous fire-clay and iron These influences will not be great, probably for the retort will generally be covered by deposited carbon yet experiments would be instructive In addition to the ordinary thermal decomposition there are taking place in the retort oxidation dehydration decomposition of heavy hydrocarbons formation of benzine and other ring compounds reduction or hydrogenation—all processes which Dr Lessing suggested from the analogy of cognate reactions the mineral constituents may well affect catalytically These processes do not take place in any fixed sequence of course most of them are reversible and overlapping and it is therefore very difficult to disentangle the threads and to trace the influence of any particular catalyst. But that the influences exist is sufficiently shown by Cooper's coal liming process which has so successfully been revived by R O Paterson of Cheltenham The addition of a minute quantity of lime to the coal does away with stopped ascension pipes and with scurfing troubles that is to say the trouble experienced in removing the deposited carbon from the retort walls Hempel ascribed the peculiar hardness of coke to the formation of silicides like carborundum from the silica and carbon during carbonization Others have proposed to neutralize the activity of a highly siliceous ash by lime Too little is unfortunately still known about the conditions in which mineral matter occurs in coal to speak definitely on such problems the different constituents would interact in the retort but the analysis of the ash does not tell much about the compounds originally present How it comes about that the coal liming process increases the yield in ammonia and diminishes the formation of organic sulphur compounds was explained in 1902 by the researches of G T Beilby and G G Henderson They proved that metals like iron copper nickel cobalt take up nitrogen from ammonia at high temperatures forming nitrides which are decomposed again by steam with liberation of ammonia and coals of different ash contents differ indeed in their ammonia yield

Again Dr Lessing continued catalysis is important in water-gas production While coke to which 10 per cent of lime is added gives a gas containing 88 per cent of hydrogen and 12 per cent of methane the addition of 50 per cent of lime will yield a gas with 77 per cent of hydrogen and 23 per cent of methane P Sabatier one of the most conspicuous workers on catalysis of our time found in conjunction with Senderens that both carbon monoxide and carbon dioxide could be hydrogenated into methane by the aid of hydrogen and of finely-divided nickel at a temperature lying between 200 deg and 250 deg Cent. Much hydrogen is however required for this formation of methane—more hydrogen than water gas contains The future of this reaction thus depends upon the cheap generation of hydrogen, itself mostly a catalytic process That the purification from sulphur of coal-gas by iron oxide is essentially catalytic hardly needs emphasis, the iron first [illegible] the sulphuretted hydrogen, and the sulphide is by the air again oxidized so that the iron oxide is restored and sulphur is deposited If this sulphur which blocks up the passages between the oxide particles could be extracted by some solvent, which should not be volatile, the process would be perfect The removal of the organic sulphur and of the carbon bisulphide from the crude gas is or was a still more difficult problem The latter difficulty has quite recently been overcome by the catalysis on a grand scale, of Charles Carpenter in conjunction with Evans and Franks by means of hydrogen in the presence of nickel at 430 deg Cent

We will not follow Dr Lessing in his references to catalysis in relation to by product works and to methodical cracking It would lead us too far into chemistry What we have said will suffice to show how important a part catalysis plays in the coal gas industry Much has been gained by systematic research and a great deal remains to be investigated the field is manifestly one for systematic scientific study

* [illegible]

Coal the Big Item*

The largest single item in the operating costs of any steam power plant is coal In most plants the purchase of coal is a matter of careful consideration and in the larger ones it is usually bought under specifications. Once the coal is in the bunkers this careful consideration stops and the actual burning of the coal is very rarely given more than a passing thought as long as the steam pressure is kept up

The men employed are paid the lowest possible living wage and are chosen more on the basis of the wages they will work for than the results they are able to produce The man who burns the coal can easily vary the efficiency of the boiler 15 10 to 15 per cent or the heat absorbed by 15 to 20 per cent yet he is at the bottom of the payroll

No revolutionary advancement has been made in power plants recently and the increased efficiency is accomplished only by taking each process separately and bringing it up to the highest standard It would therefore seem wise in attempting to increase the over all efficiency of a plant to start with the item that represents the largest expenditure and work down the list.

In office-building plants the cost of coal represents some 35 to 40 per cent of the total expenses and boiler room labor 12 to 15 per cent In big plants the cost of coal is 50 to 55 per cent and the boiler room labor 7 to 8 per cent Take a concrete case of a certain office building in New York city that employs two firemen at $800 a year each Their coal costs approximately $10 000 a year If we assume that the boiler efficiency is 60 per cent and that by paying $900 a year men could be obtained who would operate the boilers at an efficiency of 70 per cent, it would be a paying investment. The increase in wages is $600 a year The increase in boiler efficiency amounts to a reduction in coal burned of 14 3 per cent or $1 430 The net result is $830 to the good by the change not a matter of philanthropy

Any plant owner can figure out for himself what a small increase in the boiler efficiency will amount to in dollars and cents and may find it profitable. The efficiency of the boilers may be increased in several ways, but first proper equipment must be furnished Every boiler plant should be equipped with a draft gage stack thermometer and means for determining the CO_2. The cost of this whole equipment need not exceed $100 which would be repaid in a very short time

Then the firemen should be taught the use of this apparatus to determine the proper method of handling the fires to secure the highest efficiency A bonus system for savings over a certain amount would probably be productive of the best results If the firemen are able to save the plant money by their efforts, they should logically be entitled to a part of it.

* From Power

The Gas from Blast Furnaces—III*

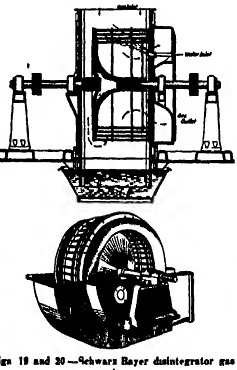
Its Cleaning and Utilization

By J. E. Johnson, Jr.

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 2041, Page 112, February 13, 1915

SCHWARZ BAYER DISINTEGRATOR GAS WASHER

The Schwarz-Bayer system of gas cleaning makes use of the disintegrator principle and its general arrangement is simple. The complete set of gas-cleaning apparatus consists of a disintegrator in connection with a saturating chamber in the form of a hood, then a fan placed immediately behind the disintegrator and finally a water separator. In case both primary and final cleaning are desired two such sets of apparatus are used, the second of which further cleans the gas which has been primarily cleaned in the first.



Figs. 19 and 20.—Schwarz Bayer disintegrator gas washer

The disintegrator as shown in Figs. 19 and 20 consists substantially of two sets of steel pins cold riveted to two steel disks which disks are set side by side and revolve in opposite directions. The pins of one revolving disk which interlace with the pins of the other revolving disk form with the water through the effect of rotation and dripping a fine spray or mist which allows a thorough mixture of the water with the gas traveling among and between the pins before leaving the apparatus.

The gases from the blast furnace pass from the raw gas mains directly into the disintegrators without previously passing through Zschocke towers or similar preliminary washer or cooler. The gas enters through the top of the hood and passes toward the center of the disintegrator while water is being introduced through the sides to the center. The hood acts to some extent as a pre-cleaner and cooler as some of the spray from the disintegrators is thrown into the hood and there comes in contact with the hot gas and rapidly evaporates simultaneously cooling the gas. By the revolution of the disintegrator the water is projected toward the periphery of the apparatus and is broken up into a fine spray; the gas mixes thoroughly with this water and is cooled and most of the dust contained in the gas is precipitated. The gases pass through the disintegrator in a current counter to that of the water.

The application of the counter-current principle enables the gas to meet cleaner and colder water in its passage through the disintegrator, hence it is better cleaned and its temperature is reduced more nearly to the temperature of the entering cooling water. This principle has the effect of materially reducing the amount of water and power consumed. Each disk is direct driven by an individual motor and the speed is determined by the degree of cleanliness desired in the gas. The gas is drawn through the disintegrator by means of a fan located immediately behind the disintegrator apparatus and passes from the fan to a water separator.

The use of pins in this apparatus as a disintegrating medium allows the passage of the gas with very little resistance and a consequent saving in power. There is also very little possibility of the dust settling on the pins and clogging up the apparatus.

FOWLER & MEDLEY VERTICAL GAS WASHER

This apparatus as shown in Fig. 21 consists of a circular cast-iron casing containing a revolving shaft running vertically through the middle. On this shaft are fixed a number of disks made either of steel or of cast iron depending upon whether the water used is alkaline or acid. Each disk is equipped with a collar separating it from the adjoining disks and each collar is punched or drilled with six holes through which six bolts pass vertically thus holding all the disks in place. The shaft is direct driven with a vertical spindle motor. Two fixed water sprays are provided for each disk diametrically opposite each other one on each side of the washer and projecting between each pair of disks. The jets of water which are introduced through nozzles having about 1/8-inch openings enter with sufficient pressure to strike the collar between the disks and as the disks revolve the water is thrown against the top and bottom of these disks and then against the outside wall of the casing creating a fine spray or mist in the space between the outer edge of the disk and the wall of the casing through which space the gas passes. The gas enters the washer at the bottom passes through this spray or mist and leaves clean at the top.

This washer can be used for either primary cleaning or final cleaning or both; in case final cleaning is desired two washers would be used in series, the first apparatus to clean the gas sufficiently for primary purposes and the second apparatus to finish the cleaning of the gas for gas-engine use.

FELD GAS WASHER

The Feld washer as shown in Fig. 22 consists of a series of superimposed sections, the bottom of each section being provided with ports for the passage of gas. The gas enters the bottom of the washer and passes from chamber to chamber to the top whence it is led away. Each section or chamber is provided with a series of cones perforated at the top and mounted upon a cast-iron spider, which is carried on a vertical shaft. The shaft is suspended at the top in a specially designed anti-friction bearing, arranged so as to reduce the power required for operation to a minimum. The water is admitted into the top of the washer and overflows from section to section through the gas ports, the dirty water saturated with dust leaving the bottom of the washer.

When the shaft revolves the cones do likewise, and the water is raised by centrifugal force along the inner sides of the cones and is atomized at the upper edge. This upper edge of each cone is a little higher than the next outer one thereby forming a certain number of horizontal sprays of water, depending on the number of cones. The upper portion of the outer cone which is somewhat higher than the inner one is perforated. The inner cones supply water to the perforated surface of the outer one. This results in the formation of a series of cascades composed of very small drops of water through which the gas must pass en route through the apparatus.

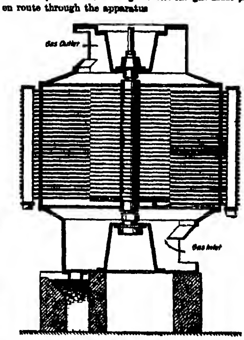


Fig. 21.—Fowler and Medley vertical gas washer

The washing is accomplished mostly in the lower sections while the upper sections perform primarily the function of cooling the gas.

For primary washing the Feld washer is constructed with seven chambers or sections, the lower three being the washing chambers, the fourth one being a separating chamber and the upper three being the cooling chambers. For final washing in the case of the gas being required for gas-engine purposes the gas after being primarily cleaned is passed through an additional washer of the same general arrangement.

KELO CENTRIFUGAL GAS WASHER

This gas washer is constructed by the Roessing-Ernest Company of Pittsburgh, Pa., and is designed to cool, clean and if necessary dry the gas in one apparatus. This washer consists substantially of a vertical outer casing, a tube whose lower end is provided with serrations extending to within a few inches of a water seal, a revolving inverted cup and a sleeve casing at-

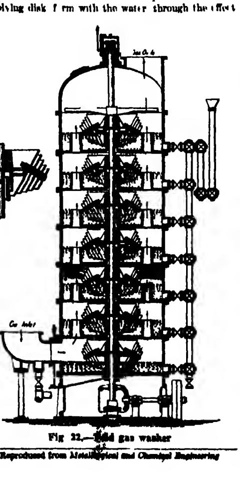


Fig. 22.—Feld gas washer

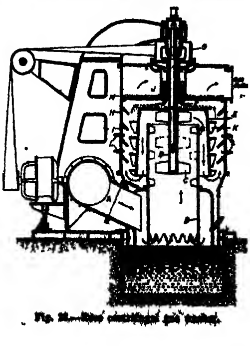


Fig. 23.—Kelo centrifugal gas washer

* Reproduced from Metallurgical and Chemical Engineering

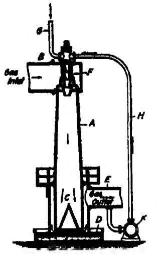


Fig 24.—Sepulchre gas washer

tached to the inverted cup The outer casing the cup the tube, and the sleeve casing are provided with shelves and vanes The apparatus is belt-driven The spindle of the rotor on which the driving pulley is fastened is hollow and the weight of the rotor is taken up by the shaft inside of this sleeve held by a ball bearing which is backed by a rubber buffer in order to equalize any irregularities during rotation

As shown in Fig 23 the hot gas enters the apparatus at the point A passes over the water a certain amount of which the gas takes up by evaporation and then passes into the tube B through the serrations at its base During its passage through this tube the gas and water vapor are subjected to a thorough beating and mixing by the action of the vanes C of the revolving sleeve casing D fastened to the top of the inverted cup E. The gas passes into this inverted cup which is rotated by the driving sleeve F and the pulley G and then flows downward, around and under the lower edge of the cup and then upward between the cup and the outer casing H The outer surface of the revolving cup is provided with concentric shelves K and the outer casing H is provided with downwardly inclined shelves I which receive the washing water from the water-sealed stuffing box J and through a series of water pipes L The water, falling on the rapidly rotating shelves of the cup is thrown by centrifugal force against the inner walls of the casing and thence flows downwardly along the inclined shelves, dripping on to the next rotating shelf, and so on In this way the gas, while subjected to a thorough whirling and beating action, has to pass upward through several films of finely divided water or spray while the water passes downward, carrying with it the separated impurities

The apparatus operates on the counter-current principle, the cleanest gas passing from the apparatus meeting the cleanest water entering the apparatus

The upper part of the casing is provided with a rack which, if so desired, can be packed with suitable drying material in case it is desired to dry the gas before leaving the apparatus.

[illegible] GAS WASHER

This system is designed as a final washer to further clean primarily cleaned and cooled gas to the degree necessary for use in gas engines The principle of this system consists in creating in a vertical tower a very fine spray or mist of water by means of an injector of the Körting type in which water under pressure is atomized by means of compressed blast-furnace gas the spray being produced by the expansion of the compressed gas An intimate mixture of the spray so formed with the dirty gas entering the apparatus is obtained by the arrangement of the apparatus

A separator is provided in connection with this apparatus which consists substantially of a cone arranged in the lower part of the tower in such a way as to leave between the base of the cone and the walls of the tower a very narrow passage through which the gases are forced over the surface of a water seal where the dust and water vapor are deposited

In the accompanying drawing Fig 24 A is the vertical tower the lower end of which terminates a short distance above the surface of the water seal D Within the lower end of the tower is arranged a conical deflector C and near the top of the tower is the gas inlet B The lower section of the tower A is surrounded by a casing which is open at the bottom and extends beneath the surface of the water in the seal A gas outlet I is provided in connection with the outer casing The Korting injector is located at F and the feed water for same is supplied through the pipe G The pressure is supplied by withdrawing a portion of the purified gas from the outlet pipe F and forcing this by the compressor K through the pipe H into the injector simultaneously with a stream of water

FINAL DRY CLEANING

(Some of these systems can also be applied to primary cleaning)

HALBERGER BETH GAS-CLEANING SYSTEM

The principle of the Halberger Beth system shown in Fig 25 is based primarily on filtering the gas through canvas bags The gas coming from the blast furnace passes through the usual dust catchers and gas mains to a cooling tower where the temperature of the gas is reduced to about 175 deg Fahr The cooling tower is arranged so that the necessary amount of cooling can be accomplished either by air or by direct contact with water depending on the temperature of the gas entering the cooler which temperature is naturally variable in accordance with blast furnace conditions

From the cooler the raw gas by means of the suction of a fan placed beyond the filters or without a fan when the pressure of the gas issuing from the furnace is sufficient passes into and through the canvas filtering bags depositing its impurities on the surface of the bags These canvas filters are contained in a series of double compartments each usually holding twelve canvas bags in rows of three to four Each bag is about 8 inches in diameter by 9 feet 9 inches long and is equipped with a ring at each 18 inches of its length to prevent entire collapse of the bag when cleaning The bags are fastened into a stationary header at the bottom this bottom end being open while the top is closed by a steel plate Each bag is connected with a shaking mechanism located outside and above the filter compartment, and at regular intervals usually about every 4 minutes, these bags are automatically shaken, a compartment at a time for a period of from 15 to 20 seconds By means of a butterfly valve, the uncleaned gas is shut off from the compartment while the shaking is in progress and cleaned gas superheated to the proper temperature of about 175 deg Fahr is forced under pressure into the compartment This causes a partial collapse of the canvas bags which in conjunction with the simultaneous shaking allows the dust to fall from the canvas The separated dust drops into a hopper beneath the sacks whence it is transferred by means of a spiral conveyor to a bin from which it is loaded into cars At the end of the cleaning period the butterfly valve automatically returns to its original position

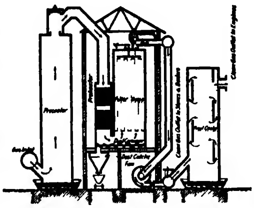


Fig 25 —Halberger Beth gas cleaning system

It is quite necessary to keep the temperature of the gas at about 175 deg Fahr as if much higher than this there is danger of scorching the bag while if lower the water vapor in the gas is deposited on the canvas and prevents proper filtration In case the gas becomes cooled below 175 deg Fahr in the cooling tower it is superheated by means of steam or by waste heat from the hot blast stoves to about this temperature before entering the filtering bags After leaving the canvas bags the gas requires no further cleaning for gas engines and is cooled down to the proper temperature in cooling towers of various designs

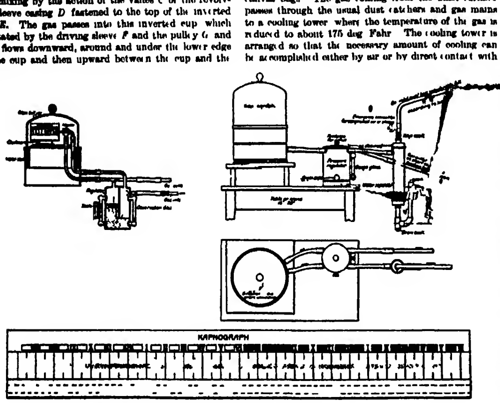
The degree of cleanliness of the gas is indicated by the clearness of the effluent water from these towers and no settling basins are required Consequently this water can be used over and over again which is a material item in districts where water is scarce A further advantage lies in the non-pollution of streams the laws relating to which are very strict in certain districts

This system utilizes the basic principle employed in the bag house system which has been used for the last 20 years in connection with recovering zinc dust from the gas issuing from zinc oxide furnaces and collecting dust from lead smelters

THE KAPNOGRAPH

This instrument shown in Fig 29 continuously indicates the relative degree of cleanliness of the blast-furnace gas going to the gas engines and is extensively used in European gas-engine stations Gas from the cleaned gas main passes through this apparatus and impinges upon a continuous recording chart upon which the dust in the gas is deposited The variations in the amount of dust in the gas are indicated by lighter or darker shades on the recording paper depending on the amount of dust deposited The flow of gas to the instrument is maintained either by the natural pressure of the gas or if this is not sufficient by an aspirator behind the outlet pipe The speed of the gas to the nozzle is kept constant by means of a regulator as shown in sketch the excess gas over the required amount escaping into the outlet pipe by passing under a partition and through a seal of water

(*To be continued*)



Specimen of strip indicating one days run at a European Gas Engine Plant

Fig. 29 —The Kapnograph

A Unique Hydraulic Plant

A novel power plant for supplying electric lighting has been put in operation in Australia The water power is derived from an artesian well from which the water issues under great pressure When shut down this pressure reaches 270 pounds and the working pressure of the jet is 100 pounds This pressure is utilized in two Pelton wheels which drive two dynamos each of 10 kilowatts capacity which supply current to a direct current two wire system comprising eighty 50 candle power metal filament lamps the number of consumers being twenty five and the voltage at consumers terminals 200 volts

Utilizing Old Equipment

An ingenious way to utilize old equipment was recently devised at a power station plant in Kansas Owing to additions made to the plant a larger smokestack was required and when it was completed the old stack which was of steel 8 feet in diameter and 200 feet high was cut down to a height of 35 feet and the lower part reinforced by boiler plate All openings were closed and tightly calked and the old chimney was thus converted into a very efficient water tank at a trifling expense.

NEW BOOKS, ETC

ASSAYING IN THEORY AND PRACTICE By F A Wraight New York Longmans Green & Co 8vo 323 pp illustrated Price $4 net

Laboratory determinations naturally stamp the ordinary pages of Prof Wraight's useful hand book In the following divisions of the work the author while disavowing any claim to exhaustiveness gives us sound and practical descriptions of dry and wet assaying and of cyanide and mill tests The book issues at the request of his past students of the Royal School of Mines and will prove to them and to other assayers a great aid in the efficient performance of their duties and a detector of the sources of error in their determinations There are plans of laboratories lists of required apparatus tables and conversion factors Prof Wraight desires the work to be considered in the light of an experiment to be followed in the event of success by a second volume dealing with more complicated analysis The wisdom of many living authorities is embodied in the text and in both text and illustration skill and thoroughness are exemplified

LINEN From the Raw Material to the Finished Product By Alfred S Moore New York Sir Isaac Pitman & Sons Ltd 12mo 132 pp illustrated

Uniform with the other volumes of the Common Commodities of Commerce series this monograph attracts our attention with a frontispiece in color showing a field of flax in bloom The Irish linen trade is sketched as it was in the past and as it is to-day The linen manufacturing system in its various aspects is presented in accurate semi popular style and there is a description of the mode of marketing The condition of the operatives is briefly referred to The author has so combined condensation with comprehensiveness that, slim as the volume is it holds a treasury of information

PRINTS A Brief Review of their Technique and History By Emil H Richter New York Houghton Mifflin Company 1914 8vo 188 pp with illustrations Price $2 net

In Prints we are given a charmingly artistic volume that cannot fail to delight any to whom pictures appeal The subject is rich in historic and artistic lore, and its possibilities have been taken full advantage of by the author and the publishers. The work is not intended for the connoisseur who has an elaborate literature at his disposal, so much as for the public who are taking an increasing interest in the broader aspects of the subject As an introduction to the graphic arts it is everything that could be desired It deals with the making of prints the origin of woodcut, the early days of engraving and the activities of Italy Germany the Netherlands France England and the United States Its many illustrations, reproductions toward which great painstaking is manifested are typical of the best and most representative work of the old and the later masters

AN INTRODUCTION TO THE STUDY OF FOSSILS (Plants and Animals) By Hervey Woodburn Shimer A M Ph D New York The Macmillan Company 1914 8vo 450 pp illustrated Price $2 40 net

It is necessary that students bring to the study of paleontology at least such knowledge of biology as will enable them to take up fossils intelligently Prof Shimer's text-book of introductory paleontology has been planned with this need in view It takes up the living forms as types and proceeds to a consideration of their response to environment, thus training the observation to reconstruct the living form from the fossil It gives a comprehensive glimpse of life in the present and of its use in the interpretation of the records of the past Many authorities and institutions have contributed illustration and criticism and the result is a work that may be placed in the hands of the student with confidence in its accuracy and in its adaptation to the requirements of preliminary study

CORK Its Origin and Industrial Uses By Gilbert E Stecher New York D Van Nostrand Company 1914 8vo 83 pp illustrated Price $1 net

Its wide application and its unique characteristics make cork an interesting subject of study Mr Stecher gives us a plain narrative of operations from the corkwood of the forest to the cork of the cellar and the kitchen It may surprise the general reader to learn that so familiar a thing has a name shrouded in mystery Its origin leads us to the romantic shores of the Mediterranean But we have said enough to indicate that this is a very readable monograph which contains as its investigations through the botany and chemistry of the substance through the processes of its manufacture on to its many uses and applications

ZOOLOGICAL PHILOSOPHY An Exposition with Regard to the Natural History of Animals By J B Lamarck Translated with an Introduction by Hugh Elliot New York The Macmillan Company 1914 8vo 410 pp Price $4 net

Lamarck's theories and observations still possess something more than historic interest and it pleases us to see so adequate a translation of his great work To such a man as Hugh Elliot we have a right to look for sterling work and a stimulating summary neither in his translation nor in his masterly introduction has he disappointed us The papers of Lamarck deal with the varied organizations of animals and the faculties derived from them with the physical maintenance of their life and the incitations to their interesting behavior and to the higher feeling and intelligence noted among the higher orders Lamarck is greatly quoted and little read The latter due doubtless to the obsolete redundant exasperating mode of expression This the translator has carefully corrected without destroying in the least any vital presentment of the work In zoology Lamarck held that all living species being known a linear series would be disclosed each of whose members differed so slightly from their immediate neighbors that the gradations would be almost imperceptible The large gaps which exist he attributes to undiscovered species His translator discloses the errors of his system while frankly acknowledging its ingenuity Lamarck rendered a distinct service to classification and his errors are rather the natural result of the restricted knowledge of his time than to any lack of observation or of perception His sociology physiology and psychology are always most interesting and deserving of the wider appreciation this translation would seem to assure him

THE DAWN OF CHRISTIANITY By Alfred W Martin A M, S T B New York D Appleton & Co 1914 12mo 221 pp Price $1 25 net

A sequel to The Life of Jesus in the Light of the Higher Criticism this series of lectures deals with the formation of the New Testament the influence of Paul and the crystallization of the existing religion into what we now know as Christianity

THE BOOK OF DESTINY And the Art of Reading Therein By Grand Orient Philadelphia David McKay 12mo 280 pp Price, $1

THE OCCULT ARTS By J W Frings Philadelphia David McKay 12mo 236 pp Price $1 net

COSMIC SYMBOLISM Being a Discussion and Exposition of Some Recondite and Obscure Points in the Art of the Kabalists the Mysteries of Sound Form and Number, and the Basic Principles of Cosmic Symbolism By Sepharial Philadelphia David McKay 12mo 296 pp Price $1 25 net

A MANUAL OF OCCULTISM By Sepharial Philadelphia David McKay 12mo 368 pp Price $1 50 net.

Take any golden stiletto that may be lying around prick any number haphazard upon the chart of fortune, and Grand Orient will answer your question through his Book of Destiny Pure rubbish, of course whose only claim upon our leniency must be upon the score of its age In The Occult Arts J W Frings attempts to justify some of them as he construes it by the conclusions of modern science He abjures the supernatural and he knows how to write In fact he writes so well that the broken link between the occult and the scientific is usually concealed with great skill In the last two books on this occult list we find that Sepharial is a man to be reckoned with, inasmuch as his knowledge of modern research seems to be as broad as his wisdom in astrology and his work is apt to influence minds with a tendency toward mysticism In Cosmic Symbolism we are told that the horoscope of Capt Smith of the Titantic and of W T Stead both point to such a death as overtook them But as to the horoscopes of the vast throng who shared their fate he is silent Some of the horoscopes must have read oppositely—or would he have us believe that Capt Smith and Mr Stead were astrological Jonahs?

A Manual of Occultism by the same author is a good exposition of the methods of astrology palmistry and many other pseudo-sciences, and shows a mentality and an application that might have been put to good use in a practical cause.

THE WONDER OF LIFE By J Arthur Thomson M A LL D New York Henry Holt & Co 8vo 658 pp illustrated Price $3 50 net

This is an unconventional introduction to Natural History and Biology taking broad views of the actual lives of living creatures and working inward In spite of the advance of Science Nature's eyes are still full of unfathomable mystery and it is the sense of this mystery which the author would convey and heighten The many colored plates are exquisitely conceived and are mounted upon a dark background that gives an air of distinction to the whole volume. Here are the bird-catching spider the sensed with its precious freightage the death's head moth and the sea-horse threading the branching red coral The text is quite enthralling and no better book could be placed in the hands of young nature students. Huxley's translation of Goethe's aphorisms fitly brings this recital of marvels to a close.

THE GERM-CELL CYCLE IN ANIMALS. By Robert W Hegner Ph D Assistant Professor of Zoology in the University of Michigan. New York The Macmillan Company 1914 8vo. 346 pp illustrated Price $1 75 net.

New and important facts in heredity are being unearthed from time to time and many of these additions to our knowledge are directly due to researches in cellular biology Prof Hegner has taken for his theme the life history of the germ-cell and chiefly of the germ-cell as it appears in animals. Condensation has been imperative so that certain phases have been but lightly touched upon, while those with which the author is most familiar personally are justifiably stressed He has couched his explanations in such language that the reader may derive from them an intelligent satisfaction even though he be unacquainted with the recent progress of cytology The period in the life of the germ-cell which the author has chosen to emphasize—partly because it has been more or less neglected—is that of the segregation of the cells in the developing egg and the visible substances concerned in the process Prof Hegner's original investigations are largely embodied in the text The germ-plasm theory is expounded in a separate chapter and a long bibliography is appended

STEAM POWER PLANTS A Treatise for Designing and Constructing Engineers Architects and Students By Charles L Hubbard, B S M E New York McGraw Hill Book Company, Inc 1914 8vo 299 pp illustrated Price $2 50 net

HEATING AND VENTILATING PLANTS By Charles L Hubbard B S, M E New York McGraw Hill Book Company Inc 1914 8vo 308 pp illustrated Price $2 50 net

These volumes are Parts I and II of a series on Power Heating and Ventilation of which Part III Isolated Plants and Small Groups is in press Each volume is complete within itself cover design, construction and management and treats the fundamentals of its subject in such a way as to render the work valuable as a text-book for students Part I deals with heat steam fuels and combustion boilers furnaces and chimneys steam engines and turbines with the details of power plant design Part II discusses principles, sets forth the advantages and disadvantages of hot air hot water steam and electric systems of heating and reviews methods for the heating and ventilation of special types of buildings The final chapter is devoted to the care and management of plants The text is interspersed with useful tables and is well and generously illustrated

HANDBOOK OF THE ROCKY MOUNTAINS PARK MUSEUM By Harlan I Smith Ottawa Published by the Department of the Interior Dominion Parks Branch, of Canada

This museum is located at Banff Alberta, and is intended eventually to fully illustrate the natural history of that portion of the Rocky Mountains lying in Alberta and British Columbia and the handbook presents in book form the labels of the museum as already printed and some that are yet to be printed and when finally completed in some future edition will constitute a convenient and popular reference and description of the chief, ... natural history objects of the region

NORTHERN PATAGONIA Character and Resources Vol I Text and maps by the Comisión de Estudios Hidrológicos Bailey Willis Director 1911 1914 New York Scribner Press 8vo 464 pp illustrated Price $6 net

This work is a credit to the Commission under whose auspices it issues It is an admirable description of the Rio Negro-Nahuel Huapi region and of the topographical geologic and economic surveys made by the Commission during 1911 1913 These surveys originated in a national policy of railroad construction which was designed to open up the rich and extensive territories of northern Argentina This is the primary step toward the greatly enlarged prosperity which must follow on the accessibility of such varied resources and speaks volumes for the foresight and practical energy of the administration In our own country where a similar lack of water was encountered geological survey relieved the situation by the discovery of artesian supply and it is our own geologists who secured by Dr Bancos-Mesia must receive recognition for the advantages gained by the field work and the scientific methods used in attacking the problems of Patagonia The text includes numerous plates of extraordinary beauty and besides the charts of the volume proper thirteen sheets of maps are provided in a separate case which is bound in uniformity with the text.

JAHRBUCH DER WISSENSCHAFTLICHEN GESELLSCHAFT FÜR FLUGTECHNIK II Band 1913-14 Berlin Verlag von Julius Springer 1914 4to 183 pp.

The society which issues this valuable yearbook was founded at Berlin April 3rd, 1912 and its membership includes the leading exponents of scientific aeronautics in all parts of Germany Its honorary president is Prince Henry of Prussia. The meetings of the society are devoted to the consideration of all kinds of scientific and technical questions relating to aeronautics and usually include lectures by specialists, followed by a general discussion. Both the lectures and the discussions are published in the yearbook, each volume of which has appeared in two parts or Lieferungen. The society has a number of committees on special subjects, such as aerodynamics, motors, safety devices, medical and psychological questions, aerology, electrostatics, etc., the reports of which are briefly abstracted in the yearbook. In short, this publication is indispensable to the student of aeronautics. The volume under review includes all the lectures delivered before the society during the year 1913 with discussions viz Motor systems by Prof Baumann An Apparatus for investigating wind-structure — the anemoclinograph of the Siemens & Halske Company by Dr H Gerdien Legal questions in aeronautics, by Dr Brythoegl The study of the upper air strata through the organization of an international network of pilot-balloon stations by Prof P Polis Aeronautics and mechanics," by Prof A Proll The present state of aeroplane construction, by Prof Reissner What health qualifications should be demanded of the air pilot? by Dr E Koschel The eyes of the aeronaut by Dr Halben The sources of the electrical charge of aircraft, by Dr F Linke; The electrical properties of balloon materials by Dr Dieckmann Hoffentlich (as the Teutonic idiom has it) the present upset in Europe will not permanently check the output of the class of literature of which this yearbook is a typical specimen

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY FEBRUARY 20 1915

Charles Allen Munn, President
Frederick Converse Beach Secretary
Orson D. Munn, Treasurer
All at 361 Broadway New York

Entered at the Post Office of New York, N Y
As Second Class Matter

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications and altogether to reflect the most advanced thought in science and industry throughout the world.

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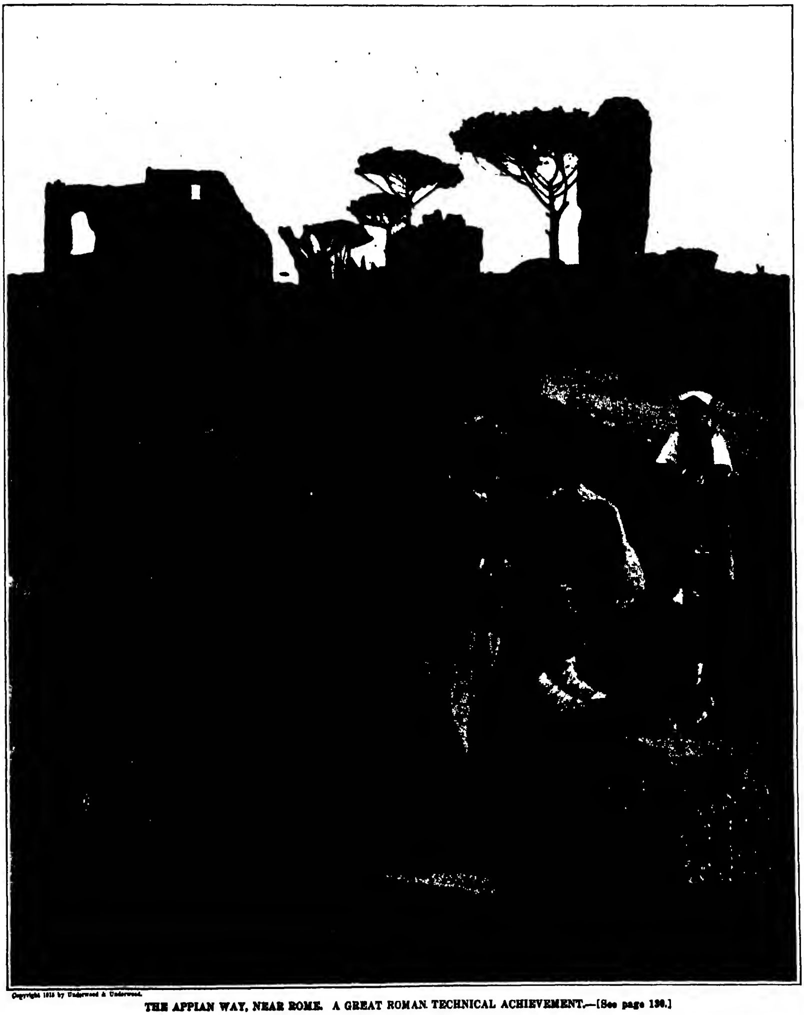
VOLUME LXXIX NUMBER 2043 | NEW YORK, FEBRUARY 27, 1915 | 10 CENTS A COPY $5.00 A YEAR



THE APPIAN WAY, NEAR ROME. A GREAT ROMAN TECHNICAL ACHIEVEMENT.—[See page 130.]

Roman Technics and Industry in Early Germany

A Commercial and Technical as well as a Political Conquest

It has been said that it was not love of conquest but economic necessity that led Rome to advance against the Germanic tribes which were constantly pushing southward. As these tribes were subdued Roman sway extended first to the line of the Rhine and the Main, and finally to the shores of the North Sea. The Romans owed the victory, it is claimed, to their superiority in the manufacture of weapons and tools and to their skill in the building of military roads, bridges, and fortifications. After the Germans had learned these arts, according to this theory, they were able not only to drive the Romans out of the conquered provinces, but soon to appear as masters on the other side of the Alps.

Cicero called the Alps a natural wall of defense against the barbarians, and when the campaigns against the Germanic tribes began the Roman legions found these mountain chains a troublesome obstacle. Hence, the Romans were driven to the building of roads over the mountains. The Roman roads, all of which started from the capital, have been divided into roads extending to Africa, Asia, the Iberian Peninsula, the Balkan Peninsula, and by way of Milan to Germany, Gaul, and Britain. In the era of its highest prosperity the roads of Rome were double the length of the equator. It was one of the principles of Roman road-building that a road connecting two places should be straight, without regard to the necessity which might thereby arise for bridges, the piercing of mountains, or the crossing of swamps. The roads had footpaths on each side, were from over thirteen feet to nearly twenty-three feet wide, and sloped toward the sides. The materials of the particular neighborhood were used as far as possible in their construction. There were nine roads across the Alps in the reign of Augustus. One lead over the Great St. Bernard (8,108 feet high) from Mediolanum (Milan) *via* Argentoratum (Strassburg) to Magontiacum (Mainz), and was only for pack-animals, not wagons. A broad wagon-road went over the Splügen to Bregenz and thence to Vindelicorum (Munich). The Romans seldom made tunnels, one of the few being that between Puteoli and Naples.

According to reports that have come down to us, Cæsar seems to have used acetic acid for loosening the rock in limestone mountains, the statement being "he burned away the rock." Livy's reference to this is explained by von Veltheim, thus: "Great piles of burning wood were set close to the rock and it was sought to direct the draft of air so that the flames played constantly against the rock, and when this was red hot or at least very hot and friable water was poured upon it, so that the sudden cooling might split it more thoroughly."

Some interesting statements respecting Roman methods of constructing roads, buildings, and fortifications in what is now the German Empire were made in a paper read last April before the District Engineering Association of Berg by Prof. Dr. Jakobi of Elberfeld and published in the *Zeitschrift des Vereines deutscher Ingenieure*. Prof. Jakobi said:

"From Mainz, which was a great storehouse for military equipments, fine roads ran to Cologne, Trier, Wiesbaden, and the fortress of Saalburg. The road from Mainz to Cologne was built on a dam 2 meters high, 8 meters broad below and 6 above. Other roads ran from Cologne to the mouth of the Weser. Corduroy or wooden roads were laid across the moors, and the remains of such a road were found by Haarmann, near Osnabrück, and given to the Deutsches Museum at Munich. This wooden road, about three meters broad, was somewhat like a railroad track. It consisted of two parallel longitudinal beams on which the cross blocks of oak rested."

The Romans preferred land travel to journeys by water; in going from Rome to Spain the long land route was chosen rather than the trip by sea. Consequently, the art of building bridges was highly developed. The mortar of lime and sand then ordinarily used could not be employed for the pillars of bridges, as it needed air for hardening. Pozzuolana earth and trass which set under water like cement were, therefore, used by the Romans in bridge work. The foundations still exist near Bingen of a bridge with eight arches built 70 B. C. In house-building, besides quarried stone, brick was largely used; in Germany the bricks were manufactured by the legions and bore the particular legion's stamp. In interesting contrast to the Roman houses are the small stone houses of the Lüneberg Moor which are supposedly of early Germanic origin. In these the floor and ceiling are made of slabs of stone over three feet thick.

The Rhine, Main, and Danube may be called the northern boundary of the Roman Empire. Strong fortifications were erected along this boundary as protection against the Germanic tribes. In front of these fortifications ran a ditch with heavy palisades, and in front of the ditch extended the Limes, a strip of land about 120 feet wide and stripped of timber so that the approach of an enemy could be seen. Through the researches of the German Imperial Limes Commission it is known that this protective clearing extended for 550 kilometers from Hönnigen on the Rhine eastward across the Taunus, reached its most northern point at Hainhaus, crossed the Main at Seligenstadt, and went on to the Danube by way of the Odenwald. There were entrances on the Limes at many spots to permit intercourse with neighbors. These entrance-gates were protected by square towers, generally a story and a half high. Traces of about nine hundred such towers have been found. The fortresses or castles lay about 250 meters behind the Limes, and the remains of some eighty of these fortresses have been discovered, the best known being Saalburg Castle, near Homburg-von-der-Höhe. Saalburg was built A. D. 11 and for nearly three centuries was one of Rome's most important strongholds on the Rhine. In 1868 a thorough investigation of the ruins was ordered and in 1896 the reconstruction of the Saalburg was begun, the plans being based on the remains and historical drawings. Prof. Jakobi describes the castle thus:

"The castle is a rectangle with rounded corners 222 meters long and 147 meters broad. The *Porta decumana*, on the side away from the foe, is 6 meters higher than the *Porta pretoria*, the entrance toward the foe. The encircling wall is about 750 meters long and 5 meters high. The Romans opened two quarries from which they obtained the quartzite blocks for the building. The lime came from Berkersheim-on-the-Nidda. The bricks were from the brickworks of the Twenty-second Legion at Nied-on-the-Main. No remains of the hoisting machinery used have been found, but Vitruvius has described such based on the pulley. The ditches before the *Porta decumana* were crossed by a bridge with a wooden railing. The *Porta decumana* had a tower on both sides, the upper story of the towers being united each with the other by a protected passageway. The 3-meter-wide walk along the wall, which was protected by a breast-high parapet, could be reached from this passageway."

The third of the fortresses toward the friendly side is said to have been called the *Retentura*; next came the *Latera pretoria*, the central portion; then the *Pretentura*, the section on the hostile side. The *Retentura* contained the *Quaestorium*, the business office of the battalion where the soldiers were paid. There were found here no less than one hundred and fifty styli, a great many writing-tablets, papyrus rolls, and ink-stands. The *Horreum* was a storeroom for provisions and held the stores of grain; in a dark part of it were kept the fresh and smoked meat and game. The *Pretorium* is a group of buildings 50 meters long and 40 meters broad through which runs the road connecting the two side-gates. It contains the commander's house, the store-room for equipments, the drill-hall, 442 square meters large, and incloses the *Atrium*, an open court for the officers. In the equipment chamber were found apparatus for war of all kinds, especially helmets and weapons. By the aid of existing remains and traditions some of the war-engines, such as catapults, were reconstructed, which when tested worked successfully.

"North of the *Atrium*," continues Prof. Jakobi, "is the sanctuary (*Sacellum*) of the garrison where the standards were kept. These were venerated by the Roman soldiers with a worship similar to a church service. On both sides of the sanctuary were chambers for the guards which could be heated. The heating apparatus was arranged as follows: The brick floor, which is covered with plaster, rests on stone pillars 0.7 meter high. Outside, protected by a projecting roof, is a sunken fire-hole in which charcoal is burned. The gases which pour out flow along under the flooring, which they slowly warm. They are then carried off by vertical clay pipes. An experimental test of the reconstructed heating apparatus gave excellent results. A reconstructed oven also proved to have been correctly made. As further protection against inclement weather, the rooms of the castle had glass windows. Judging from the remains of glassworks on the Feldberg in the Taunus, the glass used at the castle, where it was also blown, was a green soda-glass."

Much care was given to the supply of water both for the castle and the surrounding civil population. Wells were dug and, besides, water was brought from the neighboring mountain streams through hollowed tree-trunks or lead pipes. The remains of furnaces for baths found at Saalburg correspond to those known at Cologne and Pompeii. They are well constructed for their purpose and permit warm or cold water to be turned into the baths at pleasure. In the eighty wells of the civil settlement surrounding the fortress of Saalburg numerous tokens of a vanished civilization were found, such as hooks, rollers, coins, handles, buckets, and shoes. Among the shoes were sandals of wood and leather, low and high shoes, laced shoes, etc. The shoes were made of leather, tanned in the most various ways, from deerskin, goat, calf, and neat skins. Millstones for grinding grain were also found, some for handmills, some to be driven by draught-animals.

The soldiers belonging to the fortress in their free time worked at trades, but the main industrial activity was naturally in the civil settlement, where, beside Roman mechanics, tradesmen, and tavern keepers, there were also soldiers who had served their time. During the excavations the cellar of a tavern was uncovered and in it was found a large number of coins, drinking vessels, and bottles. The Saalburg Museum contains a collection of tools that have been dug up, as hammers, chisels, planes, knives, compasses, as well as what seem to be surgical instruments. The wrought iron and steel needed for weapons and tools were made directly from the ore.

Germans from the valleys of the Main, Lahn, and Rhine came to the fortress and settlements to barter skins, cattle, and game for tools, clothing, mirrors, enamel ornaments, glassware, etc. This contact with civilization taught them new ideas as to the conditions of life and led them to learn handicrafts for themselves.

Agricultural Fertilizers

With the cutting off of the potash supplies from Germany, whose rich deposits have been relied on by manufacturers of fertilizers throughout the world, people have been busily looking about for other sources for this necessary chemical. One of the first directions in which people have turned is to kelp, which is available in great quantities on our western coast, and several projects are on foot to utilize this apparently inexhaustible supply of raw material. There are, however, other sources from which potash may be obtained, and although no great quantities are to be expected in this direction, still in some localities the use of wood ashes might be considered with advantage.

Older people will remember the little inclosures attached to every farm and to many houses in the smaller towns where wood was used as a fuel, in which all of the wood ashes were carefully preserved. This formed the source of the potash used in soap-making, at the time when many farmers made their own soap; and many people spread the surplus on their land as a fertilizer. The most common custom, however, except in remote communities, was to sell these ashes to itinerant collectors, who traveled through the country in the interest of regular manufacturers of potash, and from these came the greater portion of the potash used in the earlier days of our country. Hardwood ash is much richer in potash salts than softwood ashes, and was the only kind that had a market value, although for direct application to the land any kind of ashes is better than none; and while there are few localities where wood is now used as a fuel in sufficient quantities to make the utilization of the ashes of importance, still this is one of the economies that it is as well not to lose sight of.

Besides wood ashes, those from cotton hulls are worthy of consideration in some places, as they are much richer both in potash and in phosphoric acid than the best wood ashes.

There is hardly a farm in the country where quantities of valuable fertilizing material is not constantly wasted as "trash," which is gotten out of the way in the most convenient way possible. Most of this is burned in some out-of-the-way spot and the ashes left where they lie, whereas the burning could as well have been done on cultivated land and the ashes properly distributed. [illegible]

Biochemical Systems*

And Their Function in the Development of the Organism

By Prof. W. Bechterew, of the Imperial Academy of Petrograd

Until recently the differences between human races and individuals, and the differences between animal species, have been attributed to the influence of external factors, while the internal causes of these variations have been neglected. Yet, the importance of external factors in the process of natural selection, though great, is inferior to that of the internal causes of the variations which make the process possible. The latter are the biochemical processes of nutrition and growth.

In regard to plants this statement requires no elaboration, for it is well known that the forms and colors of leaves are affected by chemicals applied to the roots of plants. The question demands more profound study in the animal kingdom, where the processes of nutrition and growth are more complex.

The general influence of nutriment on development is well known, and numerous researches have established a correlation of the biochemical process with the growth and development of certain organs. Every organ pours its specific secretion into the blood and thus affects the entire organism.

The greatest influence is exerted by the so-called glands of internal secretion, including the thyroid, parathyroid, thymus, pineal, hypophysis, subgastric, adrenal, genital, and other glands. Some of these oppose each other. The secretions of the thyroid, adrenals, and hypophysis increase the formation of leucocytes and the elimination of organic salts, while the subgastric and parathyroid secretions produce the opposite effect.

Certain glands exert a specific action on saline exchanges. Injected extract of hypophysis diminishes elimination of phosphorous by the kidneys and increases its elimination by the bowels. Thyroidine increases elimination of phosphorus and calcium by the bowels, and of magnesium by the kidneys. Removal of the parathyroids is followed by increased elimination of calcium.

The nervous influences of the glands are equally various. In general, the glands that stimulate the central nervous system depress the sympathetic system, and conversely. The subgastric and parathyroids stimulate the central and depress the sympathetic system, while the adrenals, thyroid, and hypophysis act in the opposite way.

The glands exert a regulating influence on themselves and each other, through the sympathetic system which connects them. They also affect the blood vessels and the absolute and relative numbers of the various sorts of leucocytes.

The glands act on each other by means of secreted substances which Starling has named "hormones." As a general, but not invariable rule, each gland thus acts on only one other gland.

The antagonism between different glands is indicated by many clinical observations and results of experiment. The ovaries retard the pulse and the formation of bone, both of which are accelerated by the thyroid.

The ovaries are also antagonistic to the adrenals, hypophysis and bone marrow. Adrenaline and cholin, secreted respectively by the central and peripheral parts of the adrenals, antagonize each other. The correlation between the thyroid and the thymus is very evident. The thyroid acts in concert with the adrenals and in antagonism to the subgastric. Hypertrophy of the thyroid is accompanied by hypertrophy of the central part of the adrenals, and glycosuria is caused by the combined action of the increased secretions of both glands. An injection of adrenalin produces glycosuria in a normal dog, but not in a dog which has fasted three days after ablation of the thyroid, while the removal of the subgastric increases the glycosuria caused by subsequent injection of adrenalin. Similar antagonisms exist between the thyroid and hypophysis, and between the adrenals and liver.

The glands also influence the morphological variations of the entire organism. The removal of the thyroid from young animals produces a state of cretinism, with alteration of the skeleton and retardation of the process of ossification. Lesions of the hypophysis produce the [illegible] called acromegaly and gigantism. According to researches made in our laboratory, the immediate effect of ablation of the hypophysis is increased elimination of phosphorus and nitrogen. Other researches have shown that the secretions of the hypophysis influence the development of the skeleton, the reproductive functions, and the innervation of the blood vessels, bladder, and [illegible]. Excessive secretion during growth leads to gigantism, excessive secretion after maturity causes acromegaly, while insufficient secretion produces excessive deposition of fat and atrophy of the genital glands.

An influence of the pineal gland upon the formation of the genital organs has recently been inferred from the very precocious and exaggerated development of those organs that follows lesions of the gland. The influence of the testicles on growth and the development of secondary sexual characters is well known, and is easily demonstrated by experiment. The effects of castration very early in life include a striking deficiency in hair and other cutaneous appendages, deficiency in fat, alterations in the throat and voice, changes in the color of plumage in birds, etc. These effects can be prevented by injecting an extract of testicles. The influence of the secretions of the liver upon the color of the skin has long been known by clinical observation.

We are compelled, therefore, to admit the existence in the organism of certain biochemical systems consisting of the activities of various glands. The formation of bone and muscle, for example, is promoted by the combined action of the thyroid and hypophysis, while this action is opposed by the ovaries. The development of cutaneous appendages, subcutaneous fat, the mammary glands and the larynx is affected by the genital glands and the thyroid. The coloration of the skin and its appendages is related to the activity of the solar plexus and the liver. Muscular strength is influenced by the genitals and adrenals. The development of the brain is proportional to that of the cortical layer of the adrenals, which secretes cholin. Finally, the formation of the genital organs is related directly to the activity of the hypophysis and, less directly, to that of the pineal gland.

Individual, sexual, and racial differences in man, and differences between animal species, are due chiefly to different combinations of the factors described above. The combination is determined partly by cross-breeding, and partly by external conditions.

The great and long recognized influence of crossing is probably due largely to a combination of glandular elements in the embryo and action during growth.

This view is supported by the fact that heredity presents, not a combination of all the characters of both parents, but a selection, which corresponds with the characteristic functions of certain glands. A striking example is furnished by secondary sexual characters, which are often so distinct that they might easily be taken for attributes of species. Yet they depend essentially on the presence of testicles or of ovaries. Other examples are furnished by gigantism and nanism (dwarfishness) which are sometimes hereditary. These peculiarities are caused respectively by excessive or deficient functional activity of the hypophysis and thyroid. In both cases the head is out of proportion to the body. Giants' heads are usually too small and dwarfs' heads are too large. This fact is very significant, because the occiput is formed from connective tissue and not from cartilage, the development of which is determined by the activity of the glands in question. If gigantism and nanism were caused by more general factors all giants would have large heads and all dwarfs would have small heads.

Throughout the animal kingdom, but especially in birds, the lively and quarrelsome disposition of the male, which is manifestly due to the action of the sexual glands, is associated with peculiarities in the development and color of the plumage or other cutaneous appendages, and both phenomena are exhibited most conspicuously in the breeding season.

These facts prove that the differences between species, races and individuals, including differences in temperament and mental character, are conditioned largely by the influence of glandular secretions.

The activity of the glands, however, is affected by external influences, sunshine, humidity, food, and the general conditions of life. Certain butterflies, long regarded as distinct species, have been found to be spring, summer, and autumn varieties. Many observations prove that animals are altered in size and other peculiarities by changes in climate and other external conditions. That these alterations are caused by the agency of the glands is proved by the prevalence of cretinism, nanism, and goiter in certain districts where the development and activity of the thyroid are affected by external factors which have not yet been identified. These are pathological cases, but they differ only in degree from simple morphological variations. In a mountain district in Siberia malformations of the skeleton are so common that the natives do not regard them as abnormal. The cases that I have examined show a shortening of tubular bones, caused by thyroid insufficiency in the period of growth.

It is more important to know if the glandular changes caused by external factors can be transmitted to posterity, for such transmission would explain the evolution of races and species. Here we encounter the great problem of the inheritance of acquired character, which Darwin admitted and which the neo-Darwinians, headed by Weissmann, deny. According to Weissmann's germ-plasm theory, the organism neither transmits nor acquires anything more than a predisposition, the so-called acquired characters being merely local or general alterations produced by external factors. Many modern biologists, however, agree with Darwin.

The problem has been discussed most clearly by Yves Delage, who distinguishes three classes of acquired characters: mutilations, which are never transmitted; effects of use or disuse, the transmission of which has been neither proved nor disproved; and effects of conditions of life. The third class includes pathological conditions, such as inflammations and epilepsy, the transmission of which was apparently proved by Brown-Séquard, whose results have been confirmed by some later experimenters and contradicted by others. Delage distinguishes as certainly hereditary all diatheses that affect the reproductive organs and all infections (including tuberculosis) that can be transmitted with the sexual products. The transmissibility of other diseases is difficult to prove, owing to the uncertainty, in many cases, whether they are congenital or have been acquired after birth. In regard to other effects of external conditions Delage himself is in doubt, owing to the discordance of the observations.

Standfuss found that changes in color produced in certain butterflies by temperature were transmitted to their descendants. From some butterflies (Vaucesa), which changed color under the influence of a very low temperature (23 deg. Fahr.) he obtained 41 descendants of the first generation which showed the same change in color. Of the eight pairs of these descendants that were mated one produced a single specimen that preserved the acquired coloration and three that deviated from the normal in the direction of that coloration. The progeny of the other seven pairs was normal. Fischer found that changes produced in the color and even in the form of butterflies' wings, by exposing pupæ to a temperature of 14 deg. Cent. were reproduced in 10 per cent of their progeny, and Pictet has obtained similar results with alterations produced in butterflies by abnormal diet.

By exposure to abnormal temperatures Kammerer caused the normally viviparous black salamander to lay eggs and the normally oviparous spotted salamander to bear living young, and these changes in habit were transmitted to the progeny. A curious change of instinct, artificially induced in a species of frog, was similarly transmitted.

Weissmann explains these results by the influence of external factors on the germ plasm, but, in view of the facts described earlier in this article, I am inclined to regard the direct action of those factors as being exerted on the glandular secretions, which may, in turn, affect the germ plasm. At all events, the transmission of certain acquired characters appears to be settled.

This makes it possible to free the theory of natural selection from its great blemish—the element of chance. It has always been repugnant to meet, in a theory of rigorous causality, the hypothesis of accidental variations which became fixed because they proved useful to the species. What is the origin, the cause, of these variations? It seems insufficient to regard them as results of chance. With the recognition of the part which the glandular system plays in the organism we become aware of an interacting system of physico-chemical forces in which nothing is left to chance. The variations of equilibrium of these forces under the influence of external factors determine individual differences quite definitely.

Little is yet known of the nature of this equilibrium, and its variations induced by external conditions. In general we know that abnormal glandular activity causes the prevalence of goiter and nanism in the Swiss, Ural, and Caucasus mountains, and in the marshes of the Volga. A more profound study of the etiology of these maladies, and of cretinism, myxoedema, and Basedow's disease, will ultimately furnish an explanation of the internal causes that regulate the development of organisms.

* [illegible] of an article in Revue Générale des Sciences [illegible]

Oxy-Acetylene Welding

How to Make a Complete Oxy-Acetylene Welding Outfit

By A H Waychoff

THE outfit here described was made complete by the writer who felt the need of an oxy acetylene welding outfit yet was unable to buy one owing to the high prices charged by the manufacturers for these outfits After considerable experimenting and the construction of several devices I finally was able to make this outfit at a very small expense in comparison with what they generally cost

Get a new or second hand 50-gallon range boiler *A* and plug up the hole in the bottom Then as close to the bottom as possible cut out a hole 3 in hes across *B* and fit it with a hand hole plate and yoke as shown This is for the purpose of cleaning out the sediment which is formed by the carbide dropping into the water In the hole *C* which is already in the boiler screw a short nipple an elbow and a short length of ¾ inch pipe and on the end of this pipe place a globe valve with a small funnel soldered on The top of the funnel should come about half way up the boiler This is for the purpose of filling the boiler to the required height with water Next get a piece of 10-inch pipe *D* for the carbide tank about 12 inches long and with a flange screwed on each end Cut out a hole in the top of the boiler 10 inches in diameter and rivet the carbide tank on as shown in Fig 1 using a lead gasket between the flange and the top of the boiler at *E* to make a perfectly gas tight joint Make a hopper *F* of 20 gage galvanized sheet iron which will just fit inside of the carbide tank *D* the bottom part of the hopper at *G* being 3 inches in diameter Fasten the hopper to the inside of the tank as shown by means of about four small stove bolts Next get a cover plate *H* to fit the top flange of the carbide tank *D* and tap out at one side for a 2-inch plug *I* for filling the carbide tank with fresh material Drill another hole in the center of the head for the feed rod *J* to work through

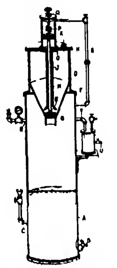


Fig 1—Acetylene generator

An old gasoline engine cylinder *K* with piston is mounted on the top of the plate *H* as shown The feed rod *J* is made of a piece of 5/8-inch steel rod The valve *L* is a piece of hard wood 1 inch thick and conical shape so as to fit into the bottom of the hopper *G* when closed Connect the feed rod up as shown one end to the valve *L* the other to the piston in the cylinder *K* A galvanized sheet iron tube 1 inch inside diameter *M* having a flange soldered on at the top at *O* is fastened to the top plate *H* by machine screws and at the bottom of the tube a funnel shaped piece *N* should be soldered on which covers the valve *L* so the carbide cannot get on the top of it The space between this valve cover *N* and the walls of the hopper should be about one half inch This allows the carbide to fall through when the valve is open Next tap out for a screw-eye in the top of the piston to which is fastened a closed coil spring *P* and a hole is drilled and tapped through the cylinder head for a hand screw *Q* which is fastened to the spring as shown At *R* mount a gage and safety valve The gage can be an ordinary steam gage registering at least 50 pounds pressure at *S* fit a half-inch pipe which should be connected up with the cylinder *K* as shown Next get a piece of 4-inch gas pipe 12 inches long *T* for the flash back arrester and fit a cover on each end and tap out 6 inches from the top for a small drain cock *U* Then run a pipe *V* from the tank through the top plate and down within 1 inch of the bottom of the arrester as shown by the dotted lines Screw in an outlet pipe with an angle valve as shown and a short piece of pipe having grooves cut in it to which the hose to the torch may be clamped on securely

Before operating this generator go all over it to see that all the joints and connections are gas-tight This may be done by putting soapy water on all the joints while there is air or other pressure in the generator If all connections are tight fill the generator with water up to the level of the funnel through pipe *C* and close the valve Set the safety valve so it will pop at about 30 pounds pressure Then loosen the spring *P* as much as possible by screwing down the hand screw *Q* Remove the filling plug *I* and fill the hopper with one half inch lumps calcium carbide Put the plug back and close the outlet valve on the flashback arrester Gradually tighten the spring *P* by means of the hand wheel *Q* which draws up the piston and opens the valve allowing some carbide to fall into the water This generates the

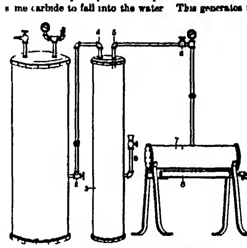


Fig 2—Oxygen generator

acetylene gas the pressure of which acting through the pipe *S* forces the piston *K* down and closes the valve *L* By a few experiments the spring can be adjusted to the proper tension so that the pressure on the piston will automatically close the valve as soon as 7 pounds pressure is reached in the generator Seven pounds is about the best working pressure for all around purposes but for higher or lower pressures a slight turn of the hand wheel will give anything desired The flashback arrestor should be kept full of water up to the drain cock

The oxygen generator shown in Fig 2 is a simple and easily made apparatus and needs very little description Get a 50-gallon range boiler plug up the bottom hole and mount a pressure gage and safety valve on one of the holes at the top as shown In the other hole fit a piece of half-inch pipe with an angle valve also a short piece of half inch pipe with grooves for attaching the hose that conveys the oxygen gas to the torch At the hole in the side of the boiler put a nipple and angle valve *2*

Get a smaller tank—the 30-gallon size—*3* being about right and pipe up to the large tank as shown at *4* A piece of pipe ½-inch *5* is run down inside tank *3* to within 4 inches of the bottom as shown by the dotted lines

To make the retort *7* get a piece of iron pipe 5 inches in diameter and 18 inches long with a flange and head for each end Mount this on suitable legs and fit a gas or gasoline burner 8 below as shown If copper pipe can be had for making the retort it is much better, but iron is very satisfactory The small tank *3*, commonly known as the scrubber should have a filling pipe 9 so that it can be filled with water within 18 inches of the top The retort *7* and scrubber *3* are connected up as shown, a valve any gage being fitted at *6*, which should now be tested out carefully for leaks at all joints before putting into operation

To use this generator make a half round tray of thin sheet iron that will just fit inside of the retort, and fill it with a mixture composed of one part manganese dioxide and three parts potassium chlorate Put the tray inside of the retort and bolt the end plates in place and light the burner See that the scrubber 3 is filled with water

Fig 4.—Complete apparatus

and that the valves *2* and *6* are open Leave the fire burning pretty strong until about 30 pounds pressure is obtained then the fire may be adjusted so as to generate the oxygen as fast as it is used From 15 to 30 pounds is about the best working pressure according to the kind of work

When the chemicals in the retort are about exhausted a good way to tell if the retort needs a new charge is to close for a few seconds valve *6* If the pressure rises on the pressure gage at *6* gas is still being formed and more chemicals are not needed If a sheet iron hood be made to fit over the retort to conform the heat, it is better

Care should be taken with the potassium chlorate to keep it in a metal container so nothing can get mixed with it as an explosive compound might easily be formed

The complete torch or blowpipe is shown in Fig 3 For the head of the torch get a 1/8-inch angle valve, *9*, and remove the hand wheel and packing nut Take out the valve stem and drill a 1/32-inch hole through it lengthwise as shown in Fig 3 *10*, also at *11* drill two holes the same size crosswise intersecting the hole *10* This makes four holes or inlets at right angles to the hole *10* Next saw off the valve stem as shown at *12* and screw it into the valve so it comes tight on its seat Then make several tips like *13* Fig 3 having holes from the size of a needle to 1/32-inch in diameter These should have threads cut on them to fit the threads on the inside of the valve bonnet, and are interchangeable for light or heavy work Next screw a piece of 1/8-inch pipe *14* Fig 3 8 inches long into the head as shown Then get a piece of 3/4-inch pipe 6 inches long with a malleable cap on each end *15* and drill and tap these caps for 1/8-inch pipe Fill the pipe *15* with mineral wool packing it tightly This pipe serves as a handle also as a flashback arrester preventing any flame from getting into the supply hose Screw this pipe or handle *15* onto *14* as shown and on its other end fit a lever gas cock *16* and a piece of pipe about 4 inches long *17* grooved to clamp the hose to.

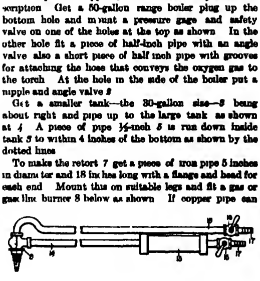


Fig 3.—The blowpipe.

Another piece of pipe, *18*, 1/8-inch in diameter and 15 inches long is bent at one end in a gooseneck, where it screws into the head *9* the gas cock, *16*, and connecting pipe, *18*, are fitted at the other end

In operation the oxygen comes into the torch through the gooseneck pipe, *18*, at a pressure of two to three times that of the acetylene which comes through the pipe, *14*. The oxygen, passing through the hole *10* Fig 3, at a greater velocity than the acetylene sucks the acetylene gas through the four holes, *11*, Fig 3, and the two gases mix, forming a combustible mixture at the tip The torch is connected up with the oxygen and acetylene generators as shown in Fig 4 by means of two pieces of high pressure hose, each about 10 feet long Be sure to attach the hose from the acetylene generators to the pipe, *14*, Fig 3, and the oxygen to pipe *18* Then turn on the acetylene gas and light it at the tip allowing it to burn for a few seconds, then gradually turn on the oxygen gas until the flame takes a sort of a bluish green color with a distinct white cone shape formed in the middle. If the torch smokes, the amount of acetylene should be reduced.

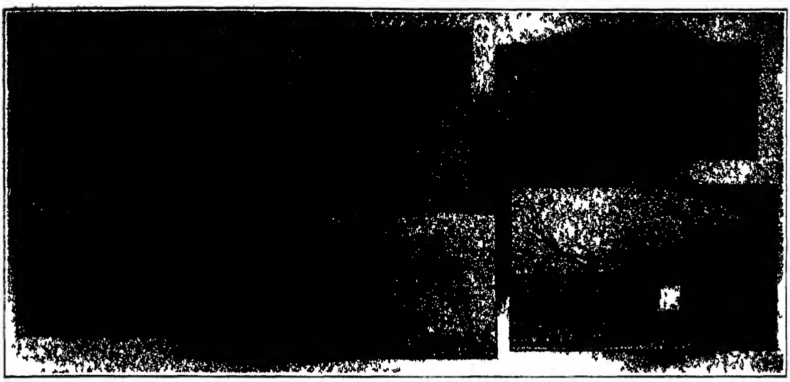


Fig. 1—Normal resting attitude of the insect carausius Fig. 2—Standing on its head Fig. 3—Extended on its back Fig. 4 Nautis or seahorse like pose Fig. 5—The wrestling bridge body bent and supported by a small stone Fig. 6—Insect as a bridge between two books its body weighted by paper slips

Catalepsy in insects

A Physiological Puzzle*

Hypnosis of Animals and Insects and Comparisons With Human Beings

WHAT the magicians did in ancient days before Pharaoh in the way of turning sticks into snakes has often been done since or its converse of turning snake into stick but it remains in great measure a physiological puzzle If the cobra in its threatening attitude be deftly caught behind the head and gently pressed it soon becomes stiff and will remain so for a considerable time, either coiled up or drawn out straight. It has passed into the strange state of animal hypnosis In 1646 the Jesuit father Athanasius Kircher described the famous experiment, de imaginatione gallinae He laid a hen on the table held it firmly for a little and drew a chalk line in front of its eyes with the result that it remained as if in catalepsy Czermak showed in 1872-1873 that this could be done with many birds, and that the chalk line was quite unnecessary The veteran entomologist Fabre tells us that he and his school companions used to put a whole flock of turkeys to sleep with their heads tucked under their wings Animal hypnosis can also be induced in mammals (guinea pig, rabbit, mouse squirrel, bat, dog cat) and this is usually effected experimentally by fastening them to a board and turning this suddenly upside down Frogs are readily susceptible and newts will also submit.

In backboned animals the state of immobility is scarcely known except in artificial conditions and can scarcely be of much importance in life It is otherwise however when we pass to the analogous death feigning" or catalepsy in certain beetles water bugs, stick insects, and spiders. The immobility occurs in natural conditions and it seems often to save the life The case of the female Galeodes is of special interest since the more than recalcitrant female passes into a convenient hypnosis when she is suddenly seized by the weaker male This may be induced artificially in the sexually mature female by gripping her suddenly in the dorsal region of the abdomen with a pair of fine forceps and raising her from the ground She remains quite passive until she is restored to earth It is very interesting to note that older females, who have paired do not pass into catalepsy, but turn fiercely on the forceps. In the same connection it is worth recalling that when we lift a shore-crab holding the shield between finger and thumb, and wave it in the air it becomes immobile, but the two sexes dispose their limbs in different ways, the female bending them in over the abdomen, as if protecting the eggs. The familiar case of the fresh-water crayfish is interesting because the creature does not pass suddenly into hypnosis, but usually resists for a considerable time It may be fixed in any position of equilibrium—on its head, on its back or even in its normal pose. The stick insect, Dixippus, which feeds at night normally assumes its protective immobile attitude under the stimulus of light, but a mechanical stimulus also serves Schmidt has recently shown that the insect can be fixed in any grotesque attitude for hours on end It has been shown that the transition from one state to the other can in this creature be effected almost in a moment

In a case like the stick insect we cannot but regard the cataleptic habit as of protective value It adds to the safety which the protective form and the protective color also help to secure The creature behaves as if it knew for it almost always disposes itself parallel to the twig to which it is attached Schleip also points out that when it lets go on being touched the elongated straight disposition of the appendages makes it easier for it to slip down among the twigs In Galeodes as we have noted the sudden passivity of the female is of importance in reproduction and a similar phenomenon has been observed in the female octopus In many cases, however it seems quite impossible to maintain that the catalepsy is protective to all Thus Fabre notes that *Scarites buparius* one of the large ground beetles, which a shake sends into a lasting catalepsy is voracious, well armored nocturnal and unpalatable What has it to do with death feigning? Cases of this sort suggest that the cataleptic tendency may be simply a concomitant of a certain type of nervous constitution and that it is only occasionally turned to advantage

According to Mangold the characteristics of human hypnosis are that it is a sleep-like state induced by suggestion that it implies a rapport between the hypnotiser and the patient and an increased amenability to suggestion that it involves an inhibited power of locomotion and of righting the body a change in muscular tonus—from initial increase to somewhat sudden decrease—and a change in sensitiveness which may amount to anesthesia and analgesia Suggestion is a physically conditioned effect, for which the physiological stimulus seems to be inadequate Little is known in regard to the hypnosis of the highest animals, like dogs and cats the amenability of which to human influence is well known but in ordinary cases it may be concluded, according to Mangold that animal hypnosis differs from man's in the absence of the suggestion the rapport, and the deeper stages It may be induced in animals without a cerebrum which indicates that the psychological factor is unimportant Physiologically considered, however the more typical forms of animal hypnosis must be ranked beside human hypnosis and studied in this light.

The resemblances are many The sleep like state is induced in man by suggestion or psychical inhibition in animals by mechanical inhibition, but in both cases sensory stimuli may assist. These stimuli may be optic (fixing the gaze on some object), or tactile (stroking the skin) or otherwise Sometimes an absence of wonted stimuli may induce the state as in the case of absolute silence The awakening may be brought about by sounds shaking currents of air or electric shocks or it may occur spontaneously There is a great specific and individual diversity in susceptibility the easier the inducing of the hypnosis the deeper and more lasting it is The muscular tonus changes characteristically (now great stiffness and again waxy flexibility) resistance to fatigue is increased Reflexes are to some extent affected by the altered tonus. Sensitiveness to touch and to pain may be greatly lessened and operations may be performed during hypnosis But the senses remain awake and, except in the deeper phases in man, memory partly persists. Anemic symptoms are sometimes observed, but there is no regular alteration in the every day functions such as the beating of the heart or the respiratory movements. Since animal and human hypnoses agree in all these respects Mangold has confidence in his thesis that they are thoroughly analogous phenomena

Finally in his interesting study he proposes a classification

1 Experimental hypnosis induced by psychical inhibition (suggestion hypothesis) (*a*) in man and (*b*) perhaps in some of the highest mammals

2 Experimental hypnosis induced by mechanical inhibition (*c*) in mammals birds reptiles and amphibians and (*d*) in crustaceans and insects

3 Natural hypnosis induced by biological stimuli (*e*) death feigning in crustaceans and insects and (*f*) catalepsy in stick insects

* "Hypnose und Katalepsie bei Tieren im Vergleich zur menschlichen Hypnose." By Ernst Mangold. From Nature.

Reinforced Concrete Aqueduct

At Borgone Italy is a good example of an aqueduct or rather flume mounted upon pillar supports the whole being built in reinforced concrete on the Hennebique system The aqueduct runs through open flat country and is about 4 650 feet in length In this way the whole structure is of solid build and is likely to withstand against deterioration longer than the usual kinds Square pillars on both sides uphold the flume part these being spaced at frequent intervals

Glass Surfaced Roads

IT is reported that an experiment is being made with a material that heretofore has been a waste product of glass factories for road making This is a thick syrupy liquid that hardens when exposed to the atmosphere forming a substance that somewhat resembles glass. A quantity of this material is said to have been mixed with crushed stone and used to surface a stretch of highway in Illinois, forming a surface that is as smooth as concrete How this surface will stand up under weather and wear will be watched with interest.

Color Photography*

A Brief Review of Its History and Details of Development

By M C. Rypinski

LIGHT according to the undulatory theory is a sensation produced on the retina of the eye by a wave motion of the ether all light traveling with the same velocity the difference in color sensation being due to differences in wave-length and frequency

Daylight or white light is a combination of color sensations and may be broken up as by a prism or a diffraction grating into its component spectral colors red orange yellow green blue indigo and violet.

Of these color sensations the red has the greatest wave-length and the lowest frequency The wave-length decreases and the frequency correspondingly increases as the violet end of the spectrum is approached

Beyond the red is an invisible portion of the spectrum the infra red and correspondingly beyond the violet there is the invisible ultra-violet both of which are characterized by their chemical action upon light sensitive substances

When rays of light encounter an object they are affected so far as color is concerned in two ways first by reflection second by absorption That is there exists a property in matter which causes a reflection from its boundary surfaces of rays of certain wave-lengths and frequencies and absorption in its mass of rays of certain other wave-lengths and frequencies. All other rays pass uninterruptedly through its mass

An opaque object is one which reflects or absorbs all light falling upon it A transparent or translucent object, on the contrary allows some light to pass through more or less unchanged For example a blue blotter has an opaque blue appearance under ordinary white light because it absorbs mainly red and green and reflects mainly blue transmitting no light In red or green light it would appear quite black A pane of clear window glass transmits all the primaries red, green and blue absorbing practically no light white light therefore entering on one side emerges unchanged on the other Cobalt glass looks blue by transmitted white light because it absorbs red and green leaving the blue to emerge practically unchanged An object due to its particular reflective and absorptive properties may therefore have a very different appearance when viewed by transmitted light as compared with reflected light and its appearance will of course vary with the color of the light source

Another variable is the color sensitiveness of the human eye The normal eye sees all colors but about four per cent of all individuals are color blind and lack the power to distinguish color in certain parts of the spectrum generally the red end In rare cases no color sensation exists at all all objects appearing white or gray in tone[1]

Clerk Maxwell has shown that all color combinations may be reproduced by a mixture of not more than three primary colors red green and blue

Painters and printers are accustomed to regard red yellow and blue as the three primaries but this is due to their working with the subtractive method of color combination where colors are laid one on top of another so that the resultant color is the original or light source color less all of the colors which the various color layers have the property of absorbing

In addition to the subtractive method of color combination there is the additive method by which the final net result is the sum of all the color components used

While most painters use the subtractive method there is a school of painting in which the color is laid on in the form of little dots arranged side by side This additive process gets its color combination from the inability of the eye to distinguish minute objects distinctly at a distance the dots merging and forming a combination image of a color resultant which is the sum of all the colors of adjacent dots

Another characteristic of colored light which plays an important part in color photography is the difference in its action on the retina and its chemical effect upon a photographic plate

It is required of a photographic image that it shall duplicate in proper light relation the object as seen by the eye however the ordinary plate or film emulsion is insensitive to the infra red and yellow portions of the spectrum fairly sensitive to the green, quite sensitive to the blue and highly sensitive to the ultra violet portion An object therefore illuminated by the uninterrupted light of a bright portion of sky (which is largely composed of ultra violet) will show more contrast between lights and shadows in the photographic image than actually exists to the eye. Also the red end of the spectrum (according to the retinal image) appears to be the brightest, while in the photographic image the blue end appears to be the brightest. It is a well known fact that when one wears dark blue or green the studio camera reproduces them as light shades, whereas dark red or yellow appear as dark shades.

In order to correct these difficulties, it is therefore necessary to find some way of making the photographic emulsion first insensitive to ultra violet second less sensitive to violet and blue, third more sensitive to yellow and red.

Considered additively the color yellow is a combination of red and green so that a transparent object which appears yellow by transmitted light is one which absorbs violet and blue and transmits red and green It is obvious therefore that the first two of the above-mentioned requirements may be satisfied if the ultra violet be eliminated and the violet and blue subdued by interposing between the emulsion and object a yellow transparent filter of just the right hue to transmit the amount of blue necessary to effect a balance between its visual and photographic images

The sensitiveness of the emulsion to yellow and red can be increased by utilizing the comparatively recent discovery that certain dyes when mixed with the emulsion render it more sensitive to the yellow portion of the spectrum Others increase the sensitiveness into the red end

Plates or films rendered sensitive to the yellow as well as to the blue and green portions of the spectrum are termed isochromatic or orthochromatic while those which are sensitive throughout the entire spectrum are termed panchromatic.

Curiously enough a panchromatic plate is least sensitive to that portion of the spectrum to which the eye is most sensitive that is, the yellow-green so that unlike ordinary plates which must be developed in a light of low luminosity to the eye (red) a yellow green dark room light of good luminosity may be used

It may be interesting to now briefly review some of the more important steps in the development of our subject The earliest experiments were conducted by Becquerel Seebeck and others commencing about 1810 and were confined to what are termed direct methods of producing photographs in color The indirect methods had not then been thought of By direct methods I mean those in which the light sensitive surface directly takes on the color of the light to which it is exposed The indirect methods contemplate the production of several pictures which are independently colored and then superposed to give the final results

These early experimenters utilized certain light sensitive silver salts which when exposed to colored light took on in a greater or lesser degree the colors falling upon them this appearance, however was not permanent as the colors soon faded In 1868 this phenomenon was explained for the first time by Zenker on the theory of the production of stationary light waves in the silver emulsion by interference of the impinging and reflected light rays.

About the same time it was discovered that many pigment colors were sensitive to light, becoming bleached through its action Wiener in investigating this phenomenon determined that a light sensitive substance can be altered only by those colored rays which the substance absorbs hence red light would have no effect on red but would bleach out blue and green green no effect on green but would bleach out blue and red etc

If therefore a light sensitive surface made up of fugitive dyes of the three primary colors is prepared and exposed under a colored transparency, a color print in duplicate of the transparency will be obtained This theory forms the basis of some of the more important development work now going forward, and it is very probable that it will lead to a satisfactory solution of the problem so far as paper prints are concerned Thus far, however, the "utocolor" paper invented by Dr Smith is the only process based on this phenomenon which is commercially available.

In the course of his experiments Dr. Smith found that certain dyes had a tendency to wander from a coating of one medium to another, as for example, from gelatine to collodion and *vice versa*, due to the affinity which acid dyes exhibit towards gelatine and basic dyes exhibit towards collodion He was able thereby to greatly simplify the selective coloring of his emulsion layers

Utocolor paper involves, however, inherent limitations as to time of printing, brilliance of color, etc., which makes it still somewhat unsatisfactory

In 1891 Prof. Lippman confirmed Zenker's theory, by evolving a direct process producing permanent color transparencies and due entirely to interference phenomena The Lippman process requires an ordinary photographic plate in a special plate holder arranged to hold mercury The plate is placed in the holder with its glass side facing outward and the mercury poured in behind to form a mirror backing for the emulsion. The plate holder is of course so designed as to prevent any leakage of the mercury On exposure in the camera the impinging light rays strike the glass plate first then pass through the emulsion and finally arrive at the mercury mirror surface, being then reflected back through the emulsion retarded in phase angle so that interference with following impinging rays takes place This interference creates stationary light planes of maximum and minimum intensity throughout the emulsion and parallel to the emulsion surface and of course affects the silver in the emulsion in maximum amount at planes of maximum intensity and in minimum amount at planes of minimum intensity After development these planes of reduced silver operate selectively on incident white light so that when viewed along the [illegible] of reflected rays the original picture in its natural colors becomes visible. This process however while capable of very beautiful results, is of scientific interest mainly and very few workers have been able to produce satisfactory plates with it.

It is now in order to mention the work done along lines which form the basis of our successful present-day processes. In 1868 Louis Ducos du Hauron, utilizing the principle laid down by Clerk Maxwell, discovered the "Three-Color Filter Process." This was an indirect additive process and was independently discovered by two other investigators, Charles Cros and Frederick Ives It consisted in taking three consecutive negatives of the colored object to be photographed, each taken through a differently colored filter so as to selectively separate on each of the three negatives a primary color component of the original object. For example one negative would be taken through a red filter which would allow only the red rays from the object to pass through and affect its negative. The second negative would be taken through a green filter, allowing only the green rays to affect its negative. The third negative would be taken through a blue filter, allowing only the blue rays to affect its negative.

Lantern slide positives of these three negatives would then be made and by means of a triple projection lantern the three images from the three slides would be superposed upon each other on the screen, after interposing between each positive and the screen its primary color filters as used in making the corresponding negatives. Each of these three superposed images would have therefore its own primary coloring and they would resolve into a combination image revealing the object in its original colors.

Ives in 1888 showed that the taking filters must collectively transmit all the rays of the spectrum of white light while the viewing or reproducing filters need transmit only narrow bands of the spectrum, representing the three primary colors.

In addition to this additive method of reproducing the original object by means of superposed colored light images, it was shown that the reproduction could be made indirectly and subtractively by superposing prints from the three negatives upon each other. These prints must be very thin and the medium holding the image must be very transparent. They must also be individually dyed to their proper color before superposing. Further, they must not be dyed with a color the same as that of the corresponding taking filter, as in the additive process [illegible] be dyed with the complementary [illegible]

* A lecture given at the eighth annual convention of the Illuminating Engineering Society Cleveland O September 21st 24th 1914

[1] For further data relative to the eye see papers by Dr H H Turner p. 79 and by Dr N M Black, p 436 vol ix, Trans. I E S

For example, the positive printed from the red filter negative is colored with a blue-green (cyan blue) dye, that from the green filter negative with a blue-red (magenta) dye, and that from the blue filter with a red green (yellow) dye.

The reason for this will be evident if we consider that here we are not dealing with overlapping lights, but with overlapping opacities in which each overlapping opacity or print absorbs part of the light transmitted by the other To make this still clearer, consider an actual case, the reproduction say of a blue blotter. One would first take three negatives, red filter, green filter and blue filter The red and green filters absorbing all blue rays would not show any image on their negatives, coming out transparent, while on the blue filter negative would be the well defined image of the blotter, more or less opaque in the high lights and transparent in the shadows

On making positives for the additive or projection process, the red and green filter positives would come out opaque and the blue filter positive would show the image of the blotter transparent in the high lights and more or less opaque in the shadows

On projecting the three positives through their respective reproduction filters, red, green and blue no light would pass through the opaque red and green positives, while the blue positive would project a blue image of the blotter on the screen, brightly blue in the high lights, darkly blue in the shadows thereby producing the desired effect.

With the subtractive process as in the additive process, the positives from the red and green filter negatives would be opaque and from the blue filter negative would show a well defined image transparent in the high lights, more or less opaque in the shadows

On dyeing, the prints from the red and green filter negatives would take up great quantities of their respective cyan blue and magenta dyes The prints from the blue filter negative would take up a small amount of yellow dye in the high lights and more of it in the shadows.

When superposed therefore and examined by ordinary white light the overlapping cyan blue and magenta dyed prints would absorb the red and green but not the blue components of the white light, the light parts of the yellow dyed print would absorb the blue falling upon it only slightly, giving a fairly bright blue reflection for the high lights, while the dark parts would absorb a greater proportion of the blue, giving a dark blue for the shadows thus again giving a correct image of the blotter

This subtractive method forms the basis of all modern color process printing and the commercially available photographic print color processes as follows Sanger-Shepherd, Ives, three-color carbon, three-color ozobrome, raydex, pinatype, polychromide, etc

Next come the single plate color processes, which have contributed largely toward making color photography commercially successful In 1869 Louis Ducos du Hauron conceived the idea of combining the three taking filters of the three-color filter process into a single tri-color filter He constructed the filter by ruling fine lines of the three primary colors, red, green and blue, on a transparent medium, coated on a glass plate, the lines being parallel, adjacent and arranged in the same consecutive alternating order of coloring all over the plate An ordinary photographic plate would be exposed in the camera with its emulsion in contact with the tri-color filter plate, the latter being on the side nearest the lens, so that the light rays would have to pass first through the filter before reaching the emulsion on the photographic plate.

The theory of this process contemplates selective action by each filter line upon the line of light passing through it, with consequent selective action upon the emulsion behind each line Thus the red parts of the image would only affect the emulsion behind the red lines on the filter; the green parts only that behind the green lines and the blue only that behind the blue lines on the filter

After exposure the plate is developed and a positive made in the usual way. The positive and the tri-color filter would then be placed together again, care being taken to align the two so that the image lines on the positive corresponding to the red, green and blue filter lines on the negative were directly in contact with the corresponding red, green and blue lines on the tri-color filter.

On looking through the combined positive and filter, or on projection upon a screen, the picture would appear in its natural colors.

The fineness of the lines on the filter and therefore in the image [illegible] the positive, is so regulated as to render them individually indistinguishable, advantage being taken of the limitation of the eye in observing minute objects, as previously pointed out. This not only [illegible] together to present a solid image, but also brings about the resultant color combinations of the primary colors necessary to bring out all the various shades of color in the object.

Du Hauron's process was not capable of commercial development, due to the lack at this period of a satisfactory 'panchromatic plate and also due to the mechanical difficulty of ruling up the filter plates

During this same year 1869, Du Hauron conceived the idea of coating the emulsion directly over the tri color filter instead of using a separate plate and after exposure and development chemically reversing the negative to form a positive image In order to overcome the mechanical difficulties involved in a ruled filter he conceived the idea of dyeing minute particles of a transparent substance with the three primary colors, mixing them together intimately and spreading them in a single layer over the glass plate to form the tri-color filter, the emulsion then being coated upon it as previously referred to

It is obvious that this would give a heterogeneous pattern of color instead of a recurring regular pattern as in the ruled line filter It is further obvious that only with a combined emulsion coating and filter as just described can such a filter be used for it would be next to impossible to align such an irregular pattern with its corresponding positive as would be necessary where the panchromatic emulsion was on a separate plate It follows, therefore that a regular geometric arrangement of colors must be used in a tri-color filter or screen (as we will now call it) where the separate single plate process is involved and either a geometric or irregular arrangement may be used with the combined single plate process

Lack of a satisfactory panchromatic emulsion and other difficulties prevented Du Hauron from achieving commercial success with the combined single plate process

During the next forty years various experimenters worked to produce a commercially successful single plate process notably Joly McDonough Lowrie and Miss Warner Their work was all very ingenious and very beautiful results were obtained especially with the Warner-Powrie process but commercially they never met with satisfactory development

In 1904 the Lumieres of Lyons France patented the well known autochrome process which represents the successful development of a combined irregular single plate process, along the lines laid down by Du Hauron This process leaves nothing to be desired so far as the production of transparencies quickly easily and with truthful color rendition is concerned It is capable of producing very beautiful lantern slides upon the exercise of somewhat greater care and experience

I will quote from a description of the process by Auguste and Louis Lumiere in a recent issue of *American Photography*

Grains of potato starch are separated by special machinery so as to reject all smaller than 10 or larger than 15 thousandths of a millimeter in diameter (0 0004 in to 0 0006 in) The grains once selected are divided into three lots which are colored orange green and violet by means of appropriate dyes The colored grains are then mixed in such proportions as to give a mixture having no dominant color The extremely intimate and homogeneous mixture of the three colored powders is then coated regularly by means of special machinery on plates of glass previously coated with a sticky varnish After this operation it is necessary to fill the spaces between the grains, which is done by another machine which coats the plates with an extremely fine carbon dust This dust is retained between the grains by the sticky varnish The plate thus prepared is rolled to flatten out the starch grains and produce a three-color mosaic The plate though covered with microscopic elements stained intense orange green and violet seems to present no coloration because the orange, green and violet rays which traverse it combine to form white light.

"How can this mosaic of colored screens give birth to colored images? The mechanism of the genesis of colors is extremely simple It is by subtraction by the partial or total obscuration of such or such a colored grain, that the formation of the most diverse colors can take place. Let us suppose that we obscure the green and the violet grains, the orange grains alone remain, and the plate, viewed with the naked eye, presents an orange coloration If we darken a single color, the hue of the plate is the resultant of light which comes through the other two If the blocking out of a given grain instead of being total, is partial, the resulting color can take the most varied tints

"The sensitive emulsion is coated over the mosaic screen and automatically registers and reproduces the colors of the object Exposure is made through the glass side of the plate so that the light traverses the colored grains and impresses the silver in proportion to the amount of the three primary colors present On treating the plate with a developer metallic silver is deposited over every grain through which light has passed in proportion to the amount of light action Thus, if the object is green every green grain will be covered with silver and if the process were stopped at this stage the image would be red because the image would be formed by the unaltered orange and violet grains This image is the complement of that which it is desired to obtain

But if we dissolve by means of appropriate chemicals the silver reduced by the first development, the green grains would be freed and rendered visible only we should still have the unaltered silver bromide covering the orange and violet grains

Let us proceed then in broad daylight to a second development This unaltered bromide will be affected by light in its turn and blackened by the developer Consequently the orange and violet grains will be masked in their turn and the green grains alone remain visible We have thus reproduced the green image after having passed through a complementary red image

This explanation can be repeated for every other color and one sees that all colors are formed by subtraction by eliminating partly or totally from the orange-green violet layer the elements of the colors complementary to the color which is to be obtained This elimination this selection is effected automatically by the colored rays themselves coming from the object photographed

In practice the manipulation of Autochromes is very simple A special yellow-orange screen is placed on the lens The plate in contact with a sheet of black cardboard to prevent scratching of the sensitive coating is loaded into the plate holder with the glass side towards the lens The same developer (metoquinone with ammonia) is employed for both the first and second development Reversal takes place in a bath of potassium permanganate acidified with sulphuric acid and all processes after the flowing of this solution over the plate take place in broad daylight With in 20 minutes of beginning work a finished positive in colors may be produced and as soon as it is dried it may be varnished and bound up like a lantern slide

It should be noted that in this process as in all other single plate processes a compensating yellow or orange filter must be used on the lens to eliminate ultra violet and cut down the violet and blue rays, as previously explained It should also be noted that due to the action of the yellow filter and tri-color screen in cutting down the actinic value of the light a great increase of exposure time over the ordinary plate is necessary varying from 25 to 100 times that required for the latter

Following quickly upon the autochrome came the Thames omnicolore and aurora or Dufay dioptichrome single plate processes each representing ingenious attempts to solve the problem in a slightly different way All have achieved fair commercial success but cannot be said to equal that of the autochrome from the standpoint of manipulation or results

In 1913 the Paget single plate process was brought out representing a development of the separate geometric screen method as laid down by Du Hauron It involves a tri-color screen printed in checkerboard pattern upon the screen plate the squares on the checker board being about 1/300 inch on a side A separate taking and viewing screen special panchromatic negative plate special orange filter and special positive plate are necessary Later the company succeeded in combining the viewing screen and the positive into a single plate This process is capable of very beautiful results is especially adapted for lantern slides and threatens to compete seriously in public favor with the autochrome process having an advantage in its possibilities of duplication from the original negative not possessed by the latter

As to the future one may say it is very hopeful The Lumieres and others are diligently working to perfect the bleach-out print process The Eastman Company has recently induced the well known English authority on this subject Dr C F Kenneth Mees to join its staff at Rochester and it is understood that he is actively directing the work along this line It is the hope of all interested in this subject that the near future may have in store for us the perfected photographic print in natural colors

German Plants in Belgium

It appears not to be generally known that many important manufacturing plants in Belgium belonged to Germans and care was taken not to injure these in the bombardments Zinc smelting is going on at Lommel and Overpelt and concerns along the Meuse are in operation

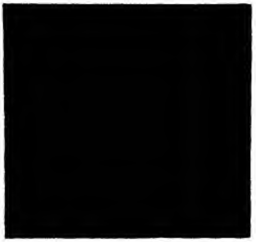


Fig 1—Diagram of the order of running lines

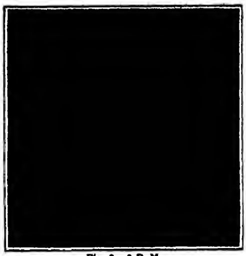


Fig 2—9 P M

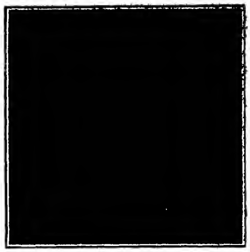


Fig 3—9 50 P M

The Spinning of a Web*

A Wonderful Bit of Engineering and Technical Skill

By Frank Cuttriss

A HEAVY thunderstorm in the afternoon having completely destroyed and washed away every trace of the web which a half grown female garden spider had made among the pines on the previous day—night we should perhaps say as we had arrived on the scene at midnight, just as she was completing it—we considered the circumstances favorable for carrying out a project we had long had in mind that of watching the construction of a spiders geometrical web from start to finish

By early evening the storm had passed leaving the earth sodden and the pine foliage sparkling with innumerable raindrops thunder rumbled all around while the clouds were still very heavy and threatening and we were a little doubtful if the weather would permit us to keep our vigil

At seven o clock the spider lay close to the under side of the branch which it had chosen for its home One could fancy it had foreseen the occurrence of storms for no more perfect shelter could be imagined the branch keeping off direct rain and the foliage around conducting all water away from the spider

At half past seven at eight o clock and half past eight, when we visited it no movement had occurred and it appeared as though our trouble would be unrewarded

We felt certain however that if it were likely to remain fine all night with the prospect of a fine morning the spider would appreciate it and by about midnight construct a new web for the morrow

Nine o clock came and although the clouds were as dense and stormy looking as ever we decided to visit our friend again and see what it was thinking This time we were rewarded for just as we reached the spot it left shelter [illegible] out to the tips of the foliage [illegible] a line to a point a few inches below ascended [illegible] but midway turned head downward and remained suspended for about fifteen minutes (see Fig 2) It then ascended to its nest branch and in a few minutes descended to a branch below

Two seconds later it ascended to its original position taking up the line with it so that at 9 25 P M practically nothing visible had been done

Ten minutes later it again emerged descended to a branch below and made fast a line which eventually formed two of the perpendicularly radiating lines. Ostensibly therefore the spider commenced the real business of making its web at 9 35 P M Next from the tips of the foliage of its nest branch it let loose a long line with a free end the object of which soon became apparent for in a few seconds it became attached at an angle of about forty degrees to foliage on the lower left hand Here the instinct—or reason—of the animal especially arrested our attention as at the time the wind was blowing from the right directly in line with the position selected for the web so that in a very few seconds the floating thread streamed out and was caught as described Practically from no other point than that chosen by the spider for setting loose this line could the end in view have been attained

We now conjectured a speedy completion of the structure mentally allowing about an hour for the work We reckoned however without our entertainer for after having done a certain amount of [illegible] about among the foliage in the vicinity the net result at 9 50 (see Fig 3) was a rough framework two upper and two lower lines radiating from a nebulous sort of ring which was evidently determined upon as the center for the coming web The architect now settled herself comfortably head downward at the junction and took a long rest Twenty minutes elapsed and our spinner appeared suddenly to realise that time was going on and set to work again until at 10 27 P M most of the supports were fixed and nine of the radiating lines were in position (see Fig 4) The spider now ascended to the nest branch and for a considerable time crept about among the foliage At 11 10 P M it descended to the center and remained there head downward for five minutes at 11 15 it was again stirring until at 11 37 the right hand support border line had been fixed as well as twenty two of the radial threads The twenty-seventh radius was fixed at 12 03 A. M after which the spider returned to the center and remained head downward (see Fig 5)

In every case where we say rested or remained in center of web or elsewhere we do not wish to convey the idea that the spider did absolutely nothing during the time although for the most part no movement was noticeable.

At 12 30 A M (see Fig 6) the last of the thirty one radial threads was in position the accompanying numbered diagram showing at a glance the order in which they were made (see Fig 1) A short space of time between the placing of all the radii after the twenty seventh was devoted to netting together at the center and fixing roughly concentric threads over larger or smaller segments which the little creature accomplished by traveling to and fro, stopping momentarily to fix the thread as it went the greater part of the central work being done after the fixing of the twenty ninth radial

A few seconds after this the spider commenced one of the most wonderful of the many astonishing features of geometric web-spinning inasmuch as it apparently demonstrates foresight and the possession by the spider of reasoning powers which enable it to use the best means to accomplish the end in view It affixed a thread near the right upper center, then by supporting itself on the radial threads and working towards the left it affixed its thread—always one remove back—in a beautiful volute of about two and three-quarter turns, which was completed at 12 40 A M (see Fig 7)

The objects of this helical line it afterwards became evident, were to keep the radiating threads properly taut and at the intended distances apart also to some extent as a scaffold for the construction of the concentric portion of the web

At 12 41 A M the outermost of the concentric threads was placed by the spider working from the top towards the left and upon arriving at the intended limit on the right it turned about and com

* From Knowledge

Fig 4—10 30 P M

Fig 5—Midnight

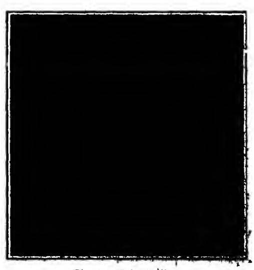


Fig. 6—12:30 A. M.

Fig 7.—12 40 A M

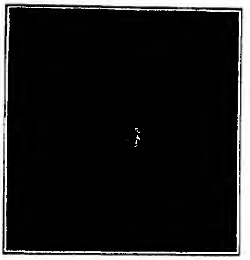


Fig 8—12 50 A M

Fig 9—1 25 A. M

menced the second thread working toward the left by way of the bottom of the web

At 12 43 A M four of these threads had been fixed the spider accomplishing the work by climbing up two threads ahead, descending to just the right distance from the thread last fixed bending its abdomen over the radius next to it, making a decided pause, and with the spinnerets getting the thread which had exuded as it proceeded, fixed at exactly the right spot holding the section just fixed with the hind foot on that side so that it should bear the strain during the operation then up the next radius, and so on over and over again (see Fig 8)

Given a good illumination through the web the most superficial observer would by this time have noticed that a very short time after each division of a concentric was fixed it changed in appearance from the finest streak of reflected light to an apparently stouter and whiter line and would recollect that none of the other lines—supports radii or central netting underwent any such change Upon closer examination and magnification this would be found to be caused by the running together into globules of a viscid matter the result probably of the spider intentionally bringing into action a special secretion We carefully noted the time elapsing between the fixing of a thread and the completion of the studding with viscid globules and found it in every case to be exactly fifty seconds.

The spider now kept on steadily at work the only variation in its movements occurring with the completely circular threads all of which were fixed by the spider working in one direction only (from left to right) instead of turning about as at the end of an incomplete circle and working the next in the opposite direction

Excepting when descending on a line the spider appeared in every case to draw out the thread from its spinnerets by means of its hinder feet used alternately, while the temporary volute or helical thread was cut away apparently by its fore feet as the spider reached it in fixing the permanent concentric lines

At 1 25 A M the finishing touch was given to one of the most perfect webs we have seen (see Fig 9) and the little wonder worker glided up a line connected with the intricate network in the center and took up its position to watch and wait on the underside of the branch the shelter of which it had left nearly four and a half hours earlier

The web constructed by this spider on the previous night—preceding the storm had two stay lines attached one on either side near the center which were affixed to the foliage about four or five inches away

The web we saw constructed had no stay lines the succeeding day being calm and without rain We noted these facts incidentally but would consider it unwise in the absence of recurring confirmatory observations to attribute them to either premonition or coincidence

In connection with the construction of geometrical webs it is interesting to note that, although the foregoing spider on three consecutive days made webs each of which contained the same number (thirty-one) of radii there appears to be nothing to determine the number of these radiating lines that any particular spider will make Perhaps we ought rather to say that the factors determining such are at present beyond our knowledge

An *Aranea umbratica* which we had under observation at the same time as our friend *diademata* constructed—also at midnight—a web twelve inches in diameter This while much larger than that of the garden spider was much more open in structure—a characteristic of this species—and contained twenty two radii only which at the outside of the web were necessarily so much further apart than those of *diademata* as to render it difficult to construct the outermost concentric threads To obviate this difficulty the spider made a temporary helical line of six coils instead of the three which extending much nearer to the outer edge enabled the spider to use it comfortably as a scaffold to get on to the next radius along which it slipped foot after foot precisely in the manner of a tit descending a cord until in position for affixing its thread

Again the web of a *Zilla x-notata* six inches only in diameter had forty radiating threads while a younger spider of the same species constructed a web containing but twenty radiating threads across the mouth of a jug

A vast field for research in this direction is open and although there is evidence of increasing interest in the ways of the much maligned spider it would seem that the fringe only of the subject has been touched and it may well be said of it as of everything else in nature that he who knows most concerning it knows best how little he knows

"Standardizing" the Art of Voice Production

The Fundamental Underlying Principle of Developing the Vocal Muscles

By Floyd S Muckey, M D

The writer considers the establishment of a real standardization of voice production to be the most vital need of the voice-teaching profession The present attempts at standardization however are not only futile but harmful, because they give the musical profession and the student public an entirely false idea of the nature and scope of this problem

All effective singing and speaking involves two things—correct voice production and interpretation. Without correct voice production our speech and song degenerate into mere mummery and disagreeable sounds This effect often becomes distressing or ludicrous to the listener on account of evident bodily strain or facial contortion. With correct voice production the matter of interpretation becomes comparatively simple. The latter depends upon the knowledge and experience of the singer, or in other words upon his mental capacity Since this mental capacity cannot be supplied by the voice teacher, his task can only be to teach the pupil how to secure the correct action of the vocal mechanism. This correct action consists in the free swing of the vocal cords, the free motion of the cartilages of the larynx, and full use of the resonance space We know that this correct action will occur if the voice mechanism is not interfered with, and we also know that incorrect action is due to this interference. There are various forms of interference, each of which leaves its impress upon the quality of the tone. The ear of the teacher may therefore be trained to hear in the quality of the tone the interference with the mechanism. This ability to diagnose interference is the first essential qualification of the voice teacher Correct voice production is involuntary and must necessarily be so while interference is voluntary Any attempt then *to do anything* directly with the mechanism or with the voice itself will inculcate interference and render voice development (development of the vocal muscles) and correct voice production an impossibility A knowledge of the nature of the voice and its mechanism and of the nature of interference must point out the method of its removal The universal tendency of the voice teachers of to-day is to attempt *to do something* with the voice and its mechanism, and hence to develop interference instead of removing it For example, all attempts to "place" the voice to get the tone "forward," to "focus" the tone, or to give it any particular "direction" mean the use of voluntary muscles in voice production. This use means interference which hampers the free action of the vocal muscles, thus weakening instead of strengthening them The result of this wrong teaching is that the voices of to-day (both speaking and singing) are mere caricatures of what they should be Furthermore these voices are at their best for only a few years at most while if they were properly produced they should last until the vocal muscles become palsied by old age More than this the hampering of the voice mechanism by interference takes the mind of the singer away from the sentiment expressed by the words. Nature never intended the singer or speaker to give any thought to the production of his voice. For this reason the voice mechanism was made involuntary, so that the whole mind could be centered upon interpretation Psychology has nothing to do with voice production but is a most important consideration in interpretation

The word *standard* means a measure The thing to be measured in the present instance is the teacher's knowledge This knowledge must be such as will enable him to diagnose and eliminate interference with the voice mechanism and to show the pupil how to develop his vocal muscles What then must the vocal teacher know to enable him to do this? He must know that the voice is a complex sound that each voice tone is composed of several simple tones varying in pitch and intensity These simple tones are called the fundamental tone (the lowest pitch) and the overtones He must know that the elements of voice tones are first pitch second volume third quality Pitch depends upon the rate of vibration of the fundamental tone volume upon the sum of the intensities of the partial tones and quality upon the number and relative intensities of these tones He must know that a wide range of pitch is absolutely dependent upon a free motion of the cartilages of the larynx and that the best volume and quality of tone cannot be secured without an unhampered swing of the vocal cords and full use of resonance It is this correct action of the mechanism which produces a strong fundamental tone—the essential in good volume and quality He must be able to recognize instantly the quality produced by a strong fundamental He must know that the conditions in the throat which produce the strong fundamental tone are such as give an unham

pered action of the vocal muscles and thus preserve the mechanism He must know that resonance is the most important factor in both volume and quality of tone, and that this is caused by the sympathetic vibration of the air in the cavities of the pharynx mouth and nose He must also know that the most rapid development of the voice (vocal muscles) is secured by the daily practices of short soft tones without interference

While there are many other things which the voice teacher should know these are the fundamental factors underlying correct voice production and must form the basis for a standardisation of this subject From the foregoing premises the conclusion is inevitable that the diagnosis and removal of interference and a knowledge of how to develop the vocal muscles are the essential qualifications of the singing teacher In the light of these statements let us analyse the recommendations which were adopted by the New York State Music Teachers Association last June This association is one of the oldest and supposedly the one most capable of putting forth a correct standard for the regulation of voice teaching The chairman of the Standardisation Committee announced that the following set of recommendations for the standardisation of voice teaching was the result of the work of various committees appointed by the association during the past twenty-six years

The Vocal Conference of the N Y S M T A. twenty-sixth Annual Convention held on June 18th 1914 unanimously adopted the following recommendations presented by the chairman looking toward the establishment of a standard of musicianship for teachers of singing who desire to become active members of the association

Resolved that before a person is considered qualified to teach singing he should demonstrate to the Examining Committee first that he possesses an ear accurate in the appreciation of differences in the pitch and quality of musical tones and in the pronunciation and enunciation of the English language second that he has sufficient pianistic ability to play simple accompaniments third that he has had at least three years continuous study with some competent teacher fourth that he possesses such elementary knowledge relating to general musicianship as is contained in such a book as Musical Essentials by Maryott fifth that he is familiar with the contents of one or more standard works dealing with Tone Production Voice Development and Interpretation sixth that he possesses the ability to impart his knowledge i e to teach seventh that he has some familiarity with teaching material in the shape of vocal exercises and songs

To show that even the first recommendation in this list is not an essential although it is by far the most pertinent the writer would merely state that Prof Halleck of Columbia University with whom he collaborated in working out the Natural Method of Voice Production was absolutely deficient in what is known as a musical ear He could not tell Yankee Doodle from Old Hundred and yet during the course of this investigation his ear became trained to hear interference just as readily as the writer's With some experience in the removal of interference he would have become a first class voice teacher This shows that while musical ear is a decided advantage to the singing teacher it is not an absolute essential On the other hand there are thousands of persons who possess this musical ear but who are absolute failures as voice teachers for they know nothing about the diagnosis and elimination of interference and the development of the vocal muscles

In considering the second qualification outlined in this standard what is the connection between playing an accompaniment and the diagnosis and elimination of interference? Does the accompaniment played by the teacher take away the interference with the voice mechanism of the pupil? The proposition only needs to be stated to show its absurdity The ability to play an accompaniment is not an essential qualification of the singing teacher

Number three states that the applicant must have had three years continuous study with some competent teacher It becomes necessary at once to define the competent vocal teacher According to our definition the competent vocal teacher is the one who can diagnose and eliminate interference and show the pupil how to attain full development of the vocal muscles and thus make use of all the capabilities of the vocal structures The competent vocal teacher should be able to eliminate all interference at once within a limited range and daily practice for from two to three years without interference should give full development of the vocal muscles with the result that there would be a perfect use of the voice mechanism or perfect tone production

It must be understood that in the beginning a tone produced without interference will be very small but will grow stronger as the vocal muscles develop

There are no singers singing without interference All of them have soft palate interference and on the loud and high tones tongue and false cord interference as well Soft palate interference (raising of the soft palate) takes away more than one-half the resonance space False cord interference prevents the free vibration of the true vocal cords while the tongue muscles interfere with the correct action of the pitch mechanism

This combined interference causes a loss of more than one-half the capabilities of the voice mechanism It greatly reduces the volume limits the range, and destroys the natural quality of the singer's voice

The result is that the voices of our public singers are greatly deficient in these three elements of voice production Such a condition of affairs could not result from competent voice instruction Such instruction covering a period of five years should show some pupils singing their loudest tones without interference. Under these conditions how is the applicant to comply with the third recommendation ?

The fourth recommendation deals with the elementary knowledge of general musicianship While this knowledge is of advantage to a voice teacher or to any one else for that matter even a profound knowledge of this subject would not aid the voice teacher in the diagnosis and elimination of interference and the development of the voice (vocal muscles) This knowledge of general musicianship is not an essential to voice teaching

Familiarity with standard works in Tone Production etc constitutes the fifth recommendation The writer is acquainted with practically all the works written upon the voice and he is in a position to state positively that there has not yet been written a work on tone (voice) production or voice development The various definitions given to the voice prove the truth of this statement. The voice is defined by different writers as vibrated breath "vitalized breath "product of the mind gift from God etc.

A logical discussion based on these definitions would result in a treatise on Meteorology (vibrated breath or air currents) Biology (vitalized breath) Psychology (product of the mind) and Theology (gift from God) This is precisely what we find in these so-called books on voice production. Instead of discussing the voice from its true definition of sound (air-waves) these authors endeavor to describe voice phenomena by a discussion of other sciences. The result is a hodgepodge of the various sciences mentioned. The terms used are necessarily figurative and can give the student no definite idea of the voice or its production. These works can, therefore, afford no assistance in the diagnosis and elimination of interference and the development of the vocal muscles.

A knowledge of the anatomy physiology and physics of voice production is essential to any intelligent discussion or teaching of the voice Since there are no standard works on the voice the student is unable to conform to this "recommendation" The sixth "recommendation" states that the applicant must have the ability to impart his knowledge. The ability to impart knowledge presupposes the possession of such knowledge. Since there are no competent vocal teachers and no standard works on the voice how is the applicant to acquire a knowledge which will enable him to diagnose and eliminate interference and instruct his pupils how to develop the vocal muscles?

In regard to the seventh 'recommendation, the teacher might be familiar with all the exercises ever used in voice development, and all the songs ever written and still know absolutely nothing about the diagnosis and removal of interference and the development of the vocal muscles. An exercise is only of value when it is performed without interference, and a song is simply a form of exercise.

This seventh recommendation" requires no knowledge essential to voice development

If anything is ever to be accomplished in voice production there must be a real standardisation for the following reasons Every voice is sound, and in every case voice production is sound production The laws which regulate this voice production are precisely the same in every singer and speaker and every mechanism which produces the voice is exactly similar Every vocal mechanism is composed of the same elements—vocal cords muscles and cartilages of the larynx, and resonance cavities The vocal cords are of the same material—yellow elastic tissue—the action of the muscles and cartilages is precisely the same in every individual and the conditions which give full use of the resonance space are identical in every speaker and singer Differences in the size and shape of these various elements account for individual characteristics of voice For these reasons there can be but one standard method of voice production An applicant might comply with all of the recommendations" of the New York State Music Teachers Association and still know nothing at all about the Standard Method of Voice Production

On the other hand an applicant might possess an accurate knowledge of this standard method and still be unable to comply with a single one of the "recommendations

The several state attempts at Standardisation are similar in character to that of New York The efforts at Standardisation thus far are therefore futile.

The only basis for a real standardisation is a knowledge of the anatomy physiology and physics of voice production and its proper application to the voice mechanism This has been carefully worked out by the voice investigation at Columbia University recently completed Any association interested in Standardisation need only standardise or measure the knowledge of its applicants by this standard knowledge

An Insoluble Seal for Letters

By "Delta"

A SEAL that will prevent surreptitious opening of letters has long been desired Most envelopes can be only too easily opened by simply steaming one end the letter is then withdrawn read, returned and resealed at one operation But a paper seal can be readily made which will render any letter proof against being opened by steaming the ends as well as the central flap being secured at the time of closing the envelope

The seal is made as follows Use a moderately glazed paper as a base for the seal Prepare a solution of gelatine consisting of 40 grains of gelatine to the ounce of water This should be allowed to soak for half an hour and then may be melted by placing the vessel into boiling water When the gelatine has melted stir the mixture well and then with a flat brush apply the gelatine solution lengthwise on the paper which should have been previously dampened Then hang up the paper to dry When dry coat the paper again brushing the sheet crosswise then dry it once more pinning the sheet at each corner to prevent it from curling When dry lay the sheet face down, and brush the back all over with amyl acetate collodion in a concentrated state then hang it up to dry again Suitable strips may now be cut from the sheet to form the envelope seals. To use these upon the envelope all that is necessary is to dip each one into a solution of common alum for about half a minute made up of 120 grains of alum in four ounces of filtered water or 90 grains of chrome alum. Then place the seal over the flap of the envelope after it has been fastened down in the usual way and, placing a piece of blotting paper upon it, rub it down with the thumb nail until the seal lies flat. It will be found that when the seal has become dry the gelatine has become insoluble It will not be softened by a lengthened period of steaming The coating of amyl acetate collodion makes the seal quite water proof, so that prolonged steaming or even scalding with hot water will not cause the seal to loosen and any attempt to remove the seal will leave a tell tale mark. The paper composing the envelope may soften and the mucilage beyond the gelatine seal liquify but the seal itself will not give way

Concentration and Co-operation in Science*

IN astronomy, for example, the great strides that have been made in the present generation can be attributed to two things first, there is the unprecedented concentration of effort Great telescopes have been erected and great observatories have been built for the purpose of solving single problems or a single group of closely related problems If these problems should remain unsolved in our time the work will be carried forward by a succeeding generation and perhaps completed many years after those who initiated it have passed away Co-operation is another powerful implement that time has placed in the hands of the astronomer, more precious to him than any telescope or any observatory can be. Thanks to it, no pressing problem appears at present above our horizon that is too great for him to attack. If you will examine the working programmes of our astronomical institutions, you will find that much the greater half of what they are doing is being carried out with direct reference to the needs and the activities of other institutions. Co-operation often makes severe demands upon the individual. It means that he must be willing to use his mental and his material equipment in furthering an impersonal plan, it means that he must sometimes subordinate his own judgment to that of others, it means that he must sometimes [illegible] that he would like to modify in some particular [illegible] these working plans.

*From an address by Prof. Frank Schlesinger, at the meeting of the American Association for the Advancement of Science.

The Chemistry of the Incandescent Gas Mantle*

The Materials Employed and the Steps Taken in its Improvement

By Dr. H. S. Miner

In responding to the invitation to tell you some of the new developments in the chemistry of the incandescent gas mantle, I very much fear that my hearers will be doomed to disappointment if I am expected to describe some startling change that has taken place in that industry. Since the wonderful and spectacular invention of the brilliant Austrian chemist, Dr Karl Auer von Welsbach, who about 30 years ago produced the incandescent gas mantle which in all justice bears his name, the growth of the industry has been marked by steady improvement rather than revolutionary changes, unless indeed we are to include that radical change in the composition of the mantle body which Dr. Auer himself made, when in the early nineties he substituted the thorium-cerium mixture for the more complex lanthanum-zirconium-cerium mantle which had comprised his first commercial mantle body. This was indeed a radical improvement, and it marked the beginning of the general adoption of the incandescent gas mantle.

I have said that the days of *radical* developments seem to be in the past, and yet I never cease to wonder at the phenomenon of the change or petrifaction of the vegetable or organic fiber, reproducing the cellulose fiber in mineral form under the influence of the Bunsen flame and giving the light-producing body with which we are familiar. And although we hear the fragility of the mantle frequently alluded to, yet when I watch its formation in this manner, which seems to be essential to its light-giving efficiency, the strength and resiliency of the mantle is a "nine days' wonder" to me.

The change in the composition of the Welsbach mantle when the mixture of 99 parts of thoria and 1 part of ceria was substituted for the earlier mixture, has ever been to my mind an invention of the highest type, involving as it did the purification of rare earth materials beyond the limits of previous knowledge, and then the development of commercial processes for the production of these rare earths in the highest state of purity.

Notwithstanding the extravagant claims made by many *pseudo* inventors, the thorium-cerium mixture still holds as the essential composition of all Welsbach mantles, and this, and this alone, is the basis of the light-giving qualities of the incandescent gas mantle: although the last quarter of a century has brought us much enlightenment upon the field of rare-earth chemistry, no satisfactory substitute has been found for this early invention of Dr. Auer's. An intimate knowledge of this industry from the very days of its infancy leaves me with an ever-increasing respect for the work of the pioneer, Dr. Auer.

In justice to the faithful and meritorious work of the many rare-earth chemists throughout the world, I would say that their work has resulted in certain changes and improvements in the mantle and burner which have decreased its cost and increased its efficiency and durability. Some of these points I will touch upon.

In the early days a purified cotton fabric was saturated with the thorium-cerium mixture made of materials of as high a state of purity as possible. The purity of the cellulose was found to be absolutely essential, and the well-known bleaching and washing processes were carried beyond the point previously thought to be necessary, and a cotton carrying less mineral substance than the best absorbent cotton was soon produced. Realizing the deleterious influence of foreign substances, such as silica, lime, magnesia, alumina, phosphoric acid, etc., it was recognized that it was just as harmful to have these elements brought to the mantle from the vegetable fiber as from the rare-earth mixture.

It was early recognized that the length of the fiber or staple of the mantle fabric had much to do with its physical strength and its durability. Long staple cottons were used exclusively in the best grade of goods, and the longer fibered ramie or China grass was looked upon with favor when it was first introduced, but it was not used with any success by mantle manufacturers until it had been successfully de-gummed, bleached and washed. The accomplishment of this complex and difficult problem resulted in the adoption of ramie as a mantle fiber, first in Germany and then in other countries. The adoption of ramie fiber made possible the mantle of the inverted or pendant type, which has since been universally adopted.

Although the staple of the fiber had been increased in length from 1½ or 1¾ inches to 5 or 6 inches by the substitution of ramie for Sea Island cotton, and that with certain advantages, especially in inverted mantles, yet the ideal had not been reached, and it remained for the artificial silk or artificial cellulose fibers to supply that ideal. The delay in the development of the artificial silk industry caused a delay in the adoption of artificial fibers as a mantle-making body, but its many striking qualities of strength, elasticity and maintained candle-power, have caused a persistence of effort that now had its reward in the arti-fiber mantle.

In the early days, the only digressions from the ideal composition of 99 per cent ThO_2 to 1 per cent CeO_2 were slight variations in these figures within narrow ranges to produce lights with varying degrees of whiteness, an increase or decrease of ceria increasing or decreasing the yellow color of the light produced. The coming of ramie fiber and the inverted type of mantle made the introduction of small percentages of hardening materials essential, and beryllium oxide was found to be an ideal substance for this purpose.

The change of fiber and of the type of the mantles as indicated has caused a complete revolution in the processes of manufacture, and notwithstanding the experience already gained, each one of these changes has called forth a line of research that had made persistent work over a period of years essential before the problem could be considered solved. This is especially true of the arti-fiber mantles, and the changes in manufacturing processes have extended to the collodion or lacquer used to strengthen the mantle for transportation, for the collodion used on the cotton or ramie mantles was found to be entirely unsuited for arti-fiber mantles.

The problem of primary importance for the chemical engineer, as related to this industry, has ever been the manufacture of thorium nitrate, and many changes in the commercial production of this substance have, of course, been effected during the score of years just past. Monazite sand has always been, and still is, the only commercial ore from which thoria could be obtained, and contains from 5 to 6 per cent ThO_2; although small deposits of thorite and thorianite with a thoria content of 50 per cent and 75 per cent respectively have served to keep alive within us an appreciation of, and longing for, a more ideal ore as a source of supply. The high price of monazite—this very low-grade ore from a thoria standpoint, with nearly 95 per cent waste—has thrown upon the thoria content, while still locked up in this phosphate rock, a heavy burden of expense and has made necessary the production of high yields and low costs of operation to keep the cost of thorium salts low enough to make them commercially available.

The first processes used in factory practice were naturally but enlargements of the well-known laboratory methods of analysis, while from this beginning have developed modification after modification, substituting cheaper and cheaper reagents and methods of manipulation until the commercial processes of to-day hardly bear even a "family resemblance" to the first process employed. These modifications are, of course, still continuing, and are made imperative by the fluctuation in price, either of the ore, of some reagent, or of the price of labor. But although there be variations in processes, there must be one unvarying standard ever before the chemist in charge and all of his associates, and that is the absolute purity of the product. Pure thoria is vitally essential, and I am gratified to be able to say for the thoria manufacturers of the world that their product is of very high grade, and is better now, notwithstanding the cheapening and shortening of processes, than it was in the beginning, although even then it was sincerely labeled "C. P."

There are various means, both chemical and physical, of checking and determining the purity of the product, but in the light of experience the most satisfactory method for both accuracy and rapidity is the manufacture of mantles from the thoria as it progresses in purity. The color of the mantle body, the color of the light produced, the presence or absence of shrinkage, the brittleness or flexibility of the mantle, give to the experienced manufacturer a more satisfactory indication of the purity of the product than do the chemical analyses, which are of necessity long and tedious.

The other essential material which must always accompany thoria is ceria, and although it is used in only about one one-hundredth the quantity as thoria, yet its chemistry is just as important and its purity just as essential. I am glad to say that this product is even purer than when Dr. Auer first used it even in larger proportions in his lathanum-zirconium-cerium mantle. The oxide of cerium then obtained was of a reddish-brown tint, while that now manufactured is of a light yellow color, the former product having been slightly contaminated with neodymium, the last traces of which were difficult to remove.

By way of variety, and in order to add zest to the work of the mantle chemist, he has also to manufacture beryllium, zirconium and neodymium, each of which he uses in a limited way, and none of these substances are really easy to produce.

Radio-chemistry has recently thrown the thoria manufacturer into the "lime-light" because of a radio-active product three hundred times stronger than radium, which occurs in and is produced from the thorium which he manufactures. I refer especially to meso-thorium, which a suffering and stricken humanity has implored the thoria manufacturers of the world to save for them, and which these manufacturers are now unitedly conserving as a substitute at least for radium.

With the possible exception of the meso-thorium just referred to, every problem we have mentioned has a bearing upon the characteristics and qualities of some or all types of incandescent gas mantles. There is another and no less important problem, however, that should be alluded to, and that is the protective coating that must be applied to a finished mantle to strengthen it temporarily for transportation. In the early part of 1888 we were dipping the finished mantle in an alcoholic solution of shellac, made slightly flexible upon drying by the addition of a little castor oil. Some essayed to strengthen the mantle by the use of paraffine, and I have in my collection of curios a mantle imbedded in a cake of paraffine, which was to be removed by the melting away of the paraffine wax.

The invention of solutions of nitro-cellulose or soluble cotton opened up a new field of research, and the knowledge gained of the many various forms of nitro-cellulose and the numerous solvents therefor, together with the knowledge and control of such characteristics as viscosity, hydroscopic effects, etc., have made it now possible to prepare collodion solutions of almost ideal qualities for mantle purposes.

And what are these ideals? A collodion must be of the proper viscosity for mantles to be dipped in and withdrawn from it without rupture or strain; it must dry quickly with a film stiff enough for the mantle to be handled with safety, and yet strong and elastic enough to resist handling and shock; it must burn off slowly enough to prevent the mantle from becoming annealed or softened, and yet it must not leave the mantle body sticking to the cap of the burner. A collodion which answers these ideal characteristics is now realized in a nitro-cellulose solution in a mixture of solvents with camphor made flexible chiefly by the use of castor oil.

I said in the beginning that the type of spectacular developments in the incandescent mantle industry were apparently over. At the close of this very general review I am, however, strongly tempted to modify this statement, and to class the commercial development of the arti-fiber or artificial silk mantle in this class of achievements.

The mantle manufacturer has held before himself for a quarter of a century and more certain ideals toward which he has earnestly striven. Some of these have been strength with elasticity, high and maintained candle-power, preservation of color and absence of shrinkage. A realization of these ideals seems finally to have been met in the mantle made from the bundle of elastic, spring-like fibers known as artificial silk, for the strength of these mantles certainly is something phenomenal, the high initial candle-power is not only maintained, but is frequently *increased*. This is made possible by the practical absence of shrinkage upon prolonged burning and by the very curious phenomenon that this mantle does not seem to collect the fine mineral dust from the atmosphere as do those manufactured from the shorter vegetable fibers, cotton and ramie, this silicious dust having a very great affinity for the basic materials of the mantle body.

The attainment of this ideal has been reached only after years of persistent research guided by many more years of experience in mantle manufacture. Old theories had to be abandoned and former methods completely changed before this mantle was commercially possible. This was a chemical problem of great complexity, and its successful solution arouses such enthusiasm within me that I am tempted to include this among the radical and spectacular developments in our industry.

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*[illegible] before the New York Section of the American [illegible] in cooperation with the American [illegible] Society and the American Gas Institute.

A clam shell from China with images of Buddha covered with mother-of-pearl

The Artificial Production of Pearls

By F. E. Chidester, A.M., Ph.D.

The shell of the mussel consists of three layers. The outside horny layer is called the *periostracum;* the middle *prismatic* layer is formed from tiny prisms of calcium carbonate separated by thin layers of the horny conchiolin found in the periostracum; the inner layer is the *nacre* or "mother-of-pearl," which consists of alternate layers of calcium carbonate and conchiolin arranged parallel to the surface. The periostracum and the prismatic layers are secreted from the edge of the mantle, while the nacre is secreted from the whole of the epidermal surface of the mantle. (Parker and Haswell.)

Many centuries ago the Chinese discovered that if foreign substances were placed between the mantle and the shell of a mussel, in many cases a coating of "mother-of-pearl" was laid down. The photograph shown herewith is of a clam now in the Conchological collection of Rutgers College. The wire images of Buddha were placed in the shell, and after a time (probably at least a year) the shell was removed from the water with the images uniformly coated with nacre.

The Japanese have developed the earlier work of the Chinese to a great enterprise under the guidance of the late Prof. Mitsukuri, opening the oysters slightly and inserting bits of sand, images, and particles of limestone, with the result that in many cases pearly excrescences, blisters or "culture pearls" are produced. These blisters are not of any great commercial value and, until recently, attempts to produce free pearls have been notably unsuccessful. A Japanese scientist, Mr. Mikimoto, has produced a few small free pearls by artificial means, but with such difficulty that the enterprise is not commercially profitable. It remained for Dr. F. Alverdes, working in the laboratory of Prof. Korschelt at Marburg, to produce free pearls by mechanical treatment.

Several causes have been suggested for the origin of pearls. Herdman thought that Cestode larvæ were the sole cause of the formation of pearls in the Ceylon pearl-oyster. (Jameson '12a.) Jameson ('02) showed that in the edible mussel, *Mytilus edulis*, pearls are formed as a result of the stimulation of a trematode worm, Gymnophallus. In this case the worm is surrounded by a sac composed of the shell-secreting epidermis, and the sac lays down concentric layers of shell substance and forms a pearl. Jameson opposes the theory of Herdman that the pearls found in the Ceylon oyster are caused by a tapeworm and considers foreign nuclei as exceptional. ('12a.) Rubbell ('11) opposes the parasitic origin of pearls in the fresh-water mussel, finding that they originate around particles of the chitinous periostracum.

Dr. Alverdes distinguished between nucleated and non-nucleated pearls. He calls a nucleus a central body not composed of one of the shell-substances. Frequently the center of a pear is a periostracum center. The nucleus of a pearl may be a parasite, an ovum or a fragment of tissue, or even a bit of quartz. ('13.) Alverdes injected into the connective tissue mantle parenchyma fragments of the shell-secreting epidermis of the mantle, and in other cases a disk of tissue containing both the epidermis and the ciliated lining of the mantle cavity. In both cases the epidermis lived if it found its way into one of the cavities of the parenchyma. (Jameson '14.) It surrounded the cavity with epidermis and formed a closed pearl-sac. Jameson concludes ('14) from the work of Alverdes and others that the real determining factors of pearl production are to be sought in the presence of an island of epidermal tissue in the sub-epidermal tissues, this island having been formed by mechanical processes as in Alverdes's experiments; by a specific parasite, as shown by Jameson in Mytilus; or as Rubbell has shown in the fresh water mussel, from a derangement of the normal mechanism of shell secretion. Alverdes's experiments proved that a nucleus is not necessary for the formation of a pearl.

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Industrial Uses of Hydrofluoric Acid*

The larger works on Chemical Technology[1] give the following uses for hydrofluoric acid:[2]

1—Liquid or gaseous hydrogen fluoride is used for etching glass. The liquid leaves a smooth transparent surface, while the gas leaves a rough opaque surface.

2—Hydrofluoric acid in connection with fluorides of the alkalies and some other additions, such as acetic acid or sulphuric acid and others, are used for frosting glass. For this purpose there is in general use a solution of acid ammonium fluoride in hydrofluoric acid. This has the trade name of "White Acid" and contains about 32 per cent NH_4FHF and 20 per cent HF. It works very quickly, e. g., the frosting of electric bulbs requires only about a minute.

3—In the manufacture of spirits from cereals to retard the development of certain bacteria. The yeast is gradually rendered immune to the effects of the acid or its salts, so that the yeast itself is not harmed, but the bacteria which causes the formation of lactic or butyric acid are killed; thus a purer product and a larger yield are obtained. Very small amounts of hydrogen fluoride are sufficient. Effront, who worked out this process, recommends from 5 to 10 grammes hydrogen fluoride per 100 liters of mash. It is not used in the manufacture of whisky, as it is feared that it may have an influence on the flavor. This seems to be well founded, as the flavor of whisky is at least partly due to ethers of the fatty acids.

Ammonium fluoride is, however, used in the fermentation industry to sterilize vessels and rubber hose. But these are always carefully washed with water before they are used again.

4—For the preparation of hydrofluosilicic acid and its salts. (Moissan.)

5—To remove alkalies from the juice of sugar beets. (Thorpe.) This is probably only a proposal and it is not likely that it has ever been carried out on a large scale.

6—To remove silica and silicates from ground anthracite to be used for the manufacture of artificial coal for electrical purposes. This process was carried out for some time on a large scale by F. v. Hardtmuth,[3] but was finally abandoned again as too expensive.

7—To purify crude graphite.

8—For treating earthenware vessels to render them more porous.

The last two uses are mentioned by Prof. Priot[4] in 1903, but I could not find any details in the literature.

9—In dyeing, the antimony acid fluoride[5] is used as a substitute for tartar emetic.

10—To remove substances which have been added to silk to make it appear heavier. (Dammer.)

This process is probably used only in the laboratory in the examination of silk fabrics.

11—In the laboratory, to dissolve and to remove either free or combined silicic acid.

12—To clean sand from cast iron and to remove obstructions from natural gas or oil wells.

I have not learned how much the last named use of hydrofluoric acid is practised.

These last two uses are apparently not practised in Europe. They are mentioned in some of the works on chemical technology, but these all refer to an article published by myself[6] in 1896.

To those uses which have been made known through different publications, the following four, which as far as I know have not been published but are in use in the United States, can be added:

Besides for cleaning cast iron, the acid is also used in large quantities either alone or mixed with sulphuric acid to clean steel pipes to be used to inclose electrical conduit wires. It is also very useful for cleaning brass and similar castings.

The particular advantages over other methods for the same purpose are: 1—This acid dissolves the sand direct, while other acids only loosen it and cause it to drop off by dissolving the metal underneath. Hydrofluoric acid also dissolves the magnetic iron oxide (Fe_3O_4) more readily than sulphuric acid or hydrochloric acid. 2—Hydrofluoric acid leaves a cleaner surface and does not penetrate into the castings as other acids seem to do. If castings which have been cleaned with sulphuric or muriatic acid are well washed and dried and afterward covered with metal or lacquer, it happens quite often that the latter are injured by excrescences starting from the metal.

In cleaning pipes for electrical conduits only the inner side is of importance; it must be perfectly smooth, so as not to injure the covered wires when they are pulled through. On the inside of metal pipes there are patches of melted slag. These can be removed with sulphuric or muriatic acid only by losing considerable metal. This slag, being a silicate, and the magnetic iron oxide, are dissolved directly by the hydrofluoric acid. Frequently a mixture of sulphuric and hydrofluoric acids is used for cleaning such pipe.

Cast steel can rarely be cleaned to advantage with hydrofluoric acid, because the loam used for molds is baked very hard and dissolves very slowly in hydrofluoric acid.

Castings and pipe are cleaned in the following manner: The acid is used in varying strengths, according to the condition of the material to be cleaned and the available time. One part 30 per cent hydrofluoric acid is mixed with 4 to 40 parts of water, which gives a solution containing 6.0 to 0.7 per cent hydrofluoric acid. The weaker acid is preferable if enough vessels are on hand to leave the castings in the acid pickle sufficiently long.

* Presented by K. F. Stahl before the Pittsburgh Section of the American Chemical Society, October 15th, 1914.

[1] Dammer, Molinari, Ed. Thorpe and Henri Moissan.

[2] It is generally known that hydrofluoric acid produces very painful inflammation if allowed to come in contact with the skin. The remedy usually recommended is washing with water and then with dilute ammonia water. This is effective only with weak acids; with stronger acids, particularly the 60 per cent, washing alone, even if done immediately, does not prevent inflammation, but if the washing is continued for about half an hour by holding the affected part under flowing water the bad effects will be prevented or at least materially reduced. Washing must, of course, begin at once after the acid has come in contact with the skin. Very dilute acid, i. e., up to 5 per cent, produces no ill effect by temporary contact with the skin.

[3] "Ueber die künstlichen Kohlen," Berlin, 19[illegible].

[4] Z. angew. Chemie, 1903, p. 195.

[5] Dammer, 1. 871.

[6] Z. angew. Chem., 1896, p. [illegible]

It requires about 12 hours to clean castings with 1 per cent acid. Comparatively more acid is required if stronger acid is used, but the time of cleaning is reduced.

Round or square wooden tanks without any protective covering are generally used. For economy in handling small castings they should be placed in a second wooden vessel perforated on the sides and slightly smaller than the first one. This has the advantage that the sand which falls off remains on the floor of the inner vessel, is lifted out with it and is thus removed from further action of the acid.

Heating accelerates the action of the acid bath, which can be used repeatedly if for every fresh batch of castings about 1/3 of the amount of acid originally used is added.

If the castings are to remain bright they should be washed with hot water as soon as they come out of the acid pickle, so that they dry off quickly; otherwise they can be washed with cold water. To the last wash water some milk of lime is usually added to prevent rusting.

Under the published uses of hydrofluoric acid, the one for etching glass was mentioned first; but it is very strange indeed that the use of strong hydrofluoric acid for *polishing cut glass*, which has been in practice for a number of years, is nowhere mentioned. It started about 18 years ago and is at present probably in use in all of the cut glass factories in this country.

The last operation in manufacturing cut glass is the polishing of the surfaces which have previously been cut into the glass. This was formerly done with oxide of iron or oxide of tin. As every plane had to be polished separately by skilled labor it was slow and expensive.

A finer polish is now obtained in the following manner: For vases and similar shapes, where the polish is required only on the outside, a wooden stopper is cemented in water-tight with paraffin or wax. Other surfaces which are not to be touched by the acid are also covered with asphaltum, wax or some similar substance. It is essential that all surfaces to be polished must be absolutely clean, and especially free of every trace of grease. To accomplish this, they are brushed with soda solution by girls who wear rubber gloves, then they are washed in clean water and after most of the water has dripped off they are dipped in the acid bath.

Generally a mixture of 1 part by weight of sulphuric acid, 66 degrees Baumé, with 3 parts 60 per cent hydrofluoric acid is employed. This mixture is in a lead vessel, large enough to submerge the largest pieces to be polished. It is placed directly in front of a ventilating tube, through which a ventilator creates a strong suction. This protects the polisher from the strong vapor given off by the acid mixture and he needs only a rubber apron and long rubber gloves for his protection. The perfectly clean and partly dried off pieces of glassware are held one at a time from ½ to 1 minute in the acid, and then immediately dipped into water.

By the action of the acid on the glass a thin crust is formed consisting of calcium fluoride, probably with some sulphate of lead and sodium or potassium fluoride. This is removed by brushing with water, after which the pieces are washed off in clean water and dipped again in the acid. The polish is usually complete after three dippings. Every piece is carefully inspected and defective spots are polished by hand; if the grinding was carefully done, this is rarely necessary.

Experiments undertaken to polish plate glass in the manner described did not produce satisfactory results. The surface obtained was glossy, but in place of being perfectly smooth, as in the case with cut glass, it was somewhat wavy. This difference may be caused by the materially different composition of the two glasses or by the apparently different manner of their production.

Buildings and monuments, particularly in industrial districts, obtain in course of time a dark color. This can be removed and the original color restored with hydrofluoric acid better and cheaper than in any other way; 15 per cent acid is generally used (30 per cent is diluted with the same volume of water). The workman wears rubber gloves and proceeds as follows: Two or three square feet of the surface are first moistened with a brush or sponge, then painted with the 15 per cent acid (for larger surfaces a whitewash brush can be used). After a minute or two the surface is scrubbed with a stiff brush and rinsed with water. The action on granite or sandstone is negligible; marble is acted on a little more and it is advisable to protect polished surfaces.

The glass roofs of greenhouses are cleaned in a similar manner. During the summer these are usually whitewashed to moderate the rays of the sun. This protective covering, on which also accumulates some dust and soot during the summer, has to be removed in the fall, as during the winter all the sunlight obtainable is needed. This is done by painting the surface of the glass with 15 per cent hydrofluoric acid, using a 6 to 8 inch whitewash brush fastened on a long pole. After a few minutes, when about 8 rows have been painted, the acid is washed off with water. In this manner the glass is made as clear and transparent as new, much better than was formerly possible with muriatic or oxalic acid.

If the houses are old and the panes of glass not absolutely tight, the glass in those houses where ferns, smilax and asparagus are raised should be cleaned before the plants are set out, because they sometimes get yellow spots from the fumes of the acid, which penetrate through the crevices even though the fumes are not perceptible to human beings.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

A Perpetual Calendar

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

I have examined with a good deal of interest the 4,000-year calendar printed in the SUPPLEMENT to the SCIENTIFIC AMERICAN on page 400, December 19th, 1914. I have done a good deal of work on calendars, and I have taken the trouble to study out this rather complex affair and find it is not reliable. I enclose a table of dates which I have looked up in this calendar, with their comparison with the correct dates. In this table there are twelve old-style dates, and Kennedy's calendar gives eleven of them wrong.

The change from old style to new style was made in England and her colonies in September, 1752, the days between September 2nd and 14th being omitted from this month; but there was no change in the succession of the days of the week. September 2nd, 1752, was Wednesday and September 14th in the same year was Thursday, being the following day. Kennedy's calendar gives both of these days as Thursday. Kennedy finds that Columbus discovered America on Monday, while history tells us it was Friday.

I have worked out a calendar very much simpler than this of Kennedy's, which covers the whole Christian era, and am sending you herewith a photographic reproduction of it. If the SCIENTIFIC AMERICAN SUPPLEMENT desires to publish this calendar I shall be glad to have it do so. The explanations given at the head of the calendar are all that is necessary to make it clear.

I note also in Kennedy's calendar that he takes no account of the fact that previous to 1662, when the English liturgy was revised, the extra day in February was inserted between February 23rd and 24th, which practice extends back to the time of Caesar. My calendar provides for these exceptional days.

W. J. SPILLMAN,

Washington, D. C.

KENNEDY'S CALENDAR.

1. Takes no account of place of intercalary day previous to 1662. (Between February 23rd and 24th).

2. Contains errors throughout. Example:

		Kennedy	True day.
October	12th, 192 (O.S.)	Wednesday	Thursday
October	12th, 292 (O.S.)	Monday	Wednesday
October	12th, 392 (O.S.)	Sunday	Tuesday
October	12th, 1092 (O.S.)	Monday	Tuesday
October	12th, 1292 (O.S.)	Friday	Sunday
October	11th, 1492 (O.S.)	Monday	Friday
January	10th, 272 (O.S.)	Sunday	Tuesday
January	10th, 572 (O.S.)	Wednesday	Sunday
January	10th, 972 (O.S.)	Sunday	Friday
January	10th, 1092 (O.S.)	Wednesday	Wednesday
August	23rd, 1114 (O.S.)	Saturday	Sunday
September	2nd, 1752 (O.S.)	Thursday	Wednesday
September	14th, 1752 (O.S.)	Thursday	Thursday

The following letter received from Mr. Kennedy explains some of the discrepancies that have been found in the use of his tables:

"The table is absolutely correct, but there are two slight errors in the examples given, which require correction.

1. "Example 1," your proof-reader has inverted the figures "89" making it read "98."

2. "Example 3," is my oversight. "In century table opposite O" should read, opposite "1", for the beginning of the century was January 1st, 1. Then follow this by "which is 6," added to 1 gives Saturday, instead of "Friday."

The Christian Era began on *Saturday* instead of "Friday."

None of the readers of the SUPPLEMENT seems to have detected this, and I am interested in having these little errors corrected

S. F. KENNEDY.

PERPETUAL CALENDAR

To find the day of the week of any date: find the year; proceed thence up the column to the month; the line of week days opposite applies to that month. Example: Jan. 5, 1919; the year 1919 occurs in the last column (at extreme right). In this column the month of January occurs opposite the line of week days beginning with Friday. Hence Jan. 1, 1919 is Friday, and Jan. 5 is Tuesday.

Leap years occupy 2 columns. For dates in Jan. and Feb., leap years are to be regarded as belonging to the 1st, and for later months the 2nd, of these two columns.

The table of years covers 4 centuries. Years in other centuries are brought within the limits of the table by adding or subtracting any exact multiple of 400 yrs. Thus the year 2092 would occupy the same place as the year 1692; the year 419 the same place as 1612, &c. Old Style dates must first be converted to New Style (see conversion table).

May	Jan Oct	Apr Jul	Sep Dec	Jun	Feb Mar Nov	Aug	Sun	Mon	Tue	Wed	Thu	Fri	Sat	May	Jan Oct	Apr Jul	Sep Dec	Jun	Feb Mar Nov	Aug
Aug	May	Jan Oct	Apr Jul	Sep Dec	Jun	Feb Mar Nov	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Aug	May	Jan Oct	Apr Jul	Sep Dec	Jun	Feb Mar Nov
Feb Mar Nov	Aug	May	Jan Oct	Apr Jul	Sep Dec	Jun	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Feb Mar Nov	Aug	May	Jan Oct	Apr Jul	Sep Dec	Jun
Jun	Feb Mar Nov	Aug	May	Jan Oct	Apr Jul	Sep Dec	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Jun	Feb Mar Nov	Aug	May	Jan Oct	Apr Jul	Sep Dec
Sep Dec	Jun	Feb Mar Nov	Aug	May	Jan Oct	Apr Jul	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Sep Dec	Jun	Feb Mar Nov	Aug	May	Jan Oct	Apr Jul
Apr Jul	Sep Dec	Jun	Feb Mar Nov	Aug	May	Jan Oct	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Apr Jul	Sep Dec	Jun	Feb Mar Nov	Aug	May	Jan Oct
Jan Oct	Apr Jul	Sep Dec	Jun	Feb Mar Nov	Aug	May	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Jan Oct	Apr Jul	Sep Dec	Jun	Feb Mar Nov	Aug	May
16	00	1601	1602	1603	16	04								1803	18	04	1805	1806	1807	18
1605	1606	1607	16	08	1609	1610	1	2	3	4	5	6	7	08	1809	1810	1811	18	12	1813
1611	16	12	1613	1614	1615	16								1814	1815	18	16	1817	1818	1819
16	1617	1618	1619	16	20	1621	8	9	10	11	12	13	14	18	20	1821	1822	1823	18	24
1622	1623	16	24	1625	1626	1627								1825	1826	1827	18	28	1829	1830
16	28	1629	1630	1631	16	32	15	16	17	18	19	20	21	1831	18	32	1833	1834	1835	18
1633	1634	1635	16	36	1637	1638								36	1837	1838	1839	18	40	1841
1639	16	40	1641	1642	1643	16	22	23	24	25	26	27	28	1842	1843	18	44	1845	1846	1847
44	1645	1646	1647	16	48	1649								18	48	1849	1850	1851	18	52
1650	1651	16	52	1653	1654	1655	29	30	31					1853	1854	1855	18	56	1857	1858
16	56	1657	1658	1659	16	60								1859	18	60	1861	1862	1863	18
1661	1662	1663	16	64	1665	1666								64	1865	1866	1867	18	68	1869
1667	16	68	1669	1670	1671	16								1870	1871	18	72	1873	1874	1875
72	1673	1674	1675	16	76	1677								18	76	1877	1878	1879	18	80
1678	1679	16	80	1681	1682	1683								1881	1882	1883	18	84	1885	1886
16	84	1685	1686	1687	16	88								1887	18	88	1889	1890	1891	18
1689	1690	1691	16	92	1693	1694								92	1893	1894	1895	18	96	1897
1695	16	96	1697	1698	1699	1700								1898	1899	1900	1901	1902	1903	19
1701	1702	1703	17	04	1705	1706								04	1905	1906	1907	19	08	1909
1707	17	08	1709	1710	1711	17								1910	1911	19	12	1913	1914	1915
12	1713	1714	1715	17	16	1717								19	16	1917	1918	1919	19	20
1718	1719	17	20	1721	1722	1723								1921	1922	1923	19	24	1925	1926
17	24	1725	1726	1727	17	28								1927	19	28	1929	1930	1931	19
1729	1730	1731	17	32	1733	1734								32	1933	1934	1935	19	36	1937
1735	17	36	1737	1738	1739	17								1938	1939	19	40	1941	1942	1943
40	1741	1742	1743	17	44	1745								19	44	1945	1946	1947	19	48
1746	1747	17	48	1749	1750	1751								1949	1950	1951	19	52	1953	1954
17	52	1753	1754	1755	17	56								1955	19	56	1957	1958	1959	19
1757	1758	1759	17	60	1761	1762								60	1961	1962	1963	19	64	1965
1763	17	64	1765	1766	1767	17								1966	1967	19	68	1969	1970	1971
68	1769	1770	1771	17	72	1773								19	72	1973	1974	1975	19	76
1774	1775	17	76	1777	1778	1779								1977	1978	1979	19	80	1981	1982
17	80	1781	1782	1783	17	84								1983	19	84	1985	1986	1987	19
1785	1786	1787	17	88	1789	1790								88	1989	1990	1991	19	92	1993
1791	17	92	1793	1794	1795	17								1994	1995	19	96	1997	1998	1999
96	1797	1798	1799	1800	1801	1802								20	00	2001	2002	2003	20	04

CONVERSION TABLE.

To convert Old Style dates to New Style:

From	To	
Jan. 1, 1,	Feb. 28, 100,	Subtract 2 days
Feb. 29, 100,	" 200,	" 1 day
" 200,	" 300,	No change
" 300,	" 500,	Add 1 day
" 500,	" 600,	" 2 days
" 600,	" 700,	" 3 "
" 700,	" 900,	" 4 "
" 900,	" 1000,	" 5 "
" 1000,	" 1100,	" 6 "
" 1100,	" 1300,	" 7 "
" 1300,	" 1400,	" 8 "
" 1400,	" 1500,	" 9 "
" 1500,	Feb. 28, 1700,	" 10 "
Feb. 29, 1700,	" 1800,	" 11 "
" 1800,	" 1900,	" 12 "
" 1900,	" 2100,	" 13 "

If the date to be converted falls on Feb. 24 to 28 in a leap year previous to 1642, add a day to the result obtained above.

Old Style dates.		Same date New Style.
Feb. 26, 1584;	26+9+1=36; 36−29	=Mar. 7, 1584.
" 27, 372;	27+1+1=29	=Feb. 29, 372.
Oct. 12, 1492;	12+9 =21	=Oct. 21, 1492.

The Gas from Blast Furnaces—IV*

Its Cleaning and Utilization

By J. E. Johnson, Jr.

Concluded from Scientific American Supplement No. 2042, Page 127, February 20, 1915

METHODS OF DETERMINING THE AMOUNT OF DUST IN BLAST-FURNACE GAS.

A method employed with good results in Europe for determining the amount of dust in the gas consists in drawing a definite quantity of the blast-furnace gas to be tested through a filter, which is weighed in a dry condition before and after the test. The apparatus for determining the amount of dust consists of a glass tube drawn out at one end and fitted at the other with a ground-glass cover which is also drawn out to a thin tube. This cover facilitates the placing of the filtering material in the tube, and during the test the cove

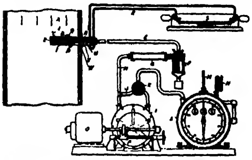

Fig. 30.—The Brown dust, moisture, and volume determinator.

is fastened to the tube by means of wire. Before the test, the glass tube, filled with suitable filtering material is placed in a drying furnace and heated at a temperature of 105 deg. Cent. until its weight is constant, which usually requires from 1 to 2 hours. The drying furnace is arranged so that several tubes can be dried simultaneously.

During the drying process air is drawn through the tubes after having previously been thoroughly dried by passing through bottles containing calcium chloride and concentrated sulphuric acid. During the drying process the tubes are weighed until no further increase in weight is observed.

In making the test, the weighed tube containing its filtering material is inserted into the gas main, a rubber stopper keeping the test-hole tight. The upper end of the tube is connected with a gas meter, which in turn is connected with a barrel filled with water. The water is allowed to flow out of the barrel and in so doing creates the necessary suction to draw the gas through the filtering tube and through the gas meter. When the necessary amount of gas has been withdrawn the tube is again dried and weighed. The increase in weight decrease the amount of dust in the quantity of gas tested.

BROWN DUST, MOISTURE, AND VOLUME DETERMINATOR FOR BLAST-FURNACE AND OTHER GASES.

This apparatus has been devised in order to accurately determine the amount of dust and moisture contained in blast-furnace gas, as well as the volume of the gas, and is used with considerable success.

Referring to the accompanying drawing, Fig. 30, *A* is a gas main conveying the gas to be tested. *B* is an aperture in the small pipe through which samples of the gas are drawn. *C* is a filtering medium within which the solid constituents of the gas are deposited. *D* is a conduit leading to the exterior of the gas main through which the filtered gas is conducted. *E* represents a flexible connection to a surface condenser, *F*. *G* represents a receptacle for some chemical, such as calcium chloride, which can be used for the purpose of taking out the moisture contained in the sample. *H* is a conduit from this moisture-removing receptacle to the rotary air pump, *I*, or through the by-pass *J* to the three-way valve *K* and thence to the gas meter *L*, where the volume of the sample is determined, together with its temperature and pressure; these latter by means of the thermometer *M* and the U-tube *N*, respectively. An electric motor, *O*, is used to operate the pump *I* through the variable-speed drive *P*.

An indication of the velocity of gas or gases in conduit *A* is transmitted through aperture *Q* in the sample pipe and conduit *R* to horizontal pressure gage *S*; also an indication of the velocity of gas or gases after passing aperture *B*, is transmitted from aperture *T* through conduit *U* to horizontal pressure gage *S*. It is evident that changes of the velocity of the gas or gases in aperture *B* of sample pipe, produced by the suction of pump *I* or by pressure in gas main *A*, are indicated, and can be accurately controlled and made equal to the velocity of the gas or gases in conduit *A*, the gas main, such indicator being the oil piston shown in glass tube forming a part of the velocity gage *S*.

The method of operating this apparatus is as follows: The dry weights of the filtering medium *C*, of the receptacle *G*, containing the calcium chloride, and of the measuring flask attached to surface condenser *F*, are very carefully determined. They are then inserted in the apparatus, and the sample pipe is then inserted in the gas main, a tight connection being made between flange *W* and bushing *V*. The meter reading is noted. At the same time that the sample pipe is inserted in the gas main *A*, the time is noted, and the rotary pump *I* started. The speed is then so regulated that the oil piston in the horizontal pressure gage *S* is maintained in equilibrium. This indicates that the velocity in aperture *B* is exactly equal to the velocity in gas main *A*, this condition having been determined by a measured amount of gas in gas main *A*, and the proper proportioning of aperture and conduits in the sample pipe during the calibration tests. This condition is maintained for an definite length of time and the sample pipe is then withdrawn from gas main *A*. The meter reading, multiplied by the ratio of area of aperture *B* to area of gas main *A*, gives the total amount of gas passing through gas main *A* in the elapsed time. The difference between the dry weight of the filtering medium *C*, before and after the test, divided by the number of cubic units shown by the meter, gives the weight of dust per cubic unit. The moisture per cubic unit of gas is found in a similar manner from the sum of the weights of the water in drying receptacle *G*, the water caught in the measuring flask attached to surface condenser *F*, and the weight of water retained in the filtering medium *C*.

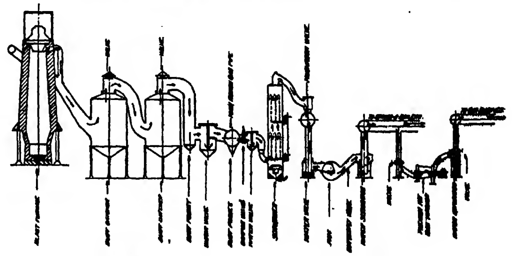

Fig. 31.—The course of the gas through the cleaning process to stoves, boilers, and engines.

Figs. 31 to 34 are reproduced from Mr. Diehl's paper as showing approved types of construction. The text of Mr. Diehl's concerns itself principally with operation and will be quoted in dealing with that subject.

In addition to the processes so clearly described by Mr. Forbes, there are various others designed to remove the dust from the gas in the dry state, but as these have had no extensive application for the blast furnace process, they may be omitted here.

Even since the time of Mr. Forbes' paper there has been an extensive development in Europe of the Halberger-Beth process of which there are now almost thirty plants in use in Europe and the number has been rapidly increasing. American furnacemen have been slow to take up this process and have acted in this matter along the same line as in many other cases; where an apparatus requires careful supervision or where its maintenance charges are high, operating economies secured by its use are disregarded. The same has been true in regard to the gas engine, by-product coke-oven and many other kinds of apparatus.

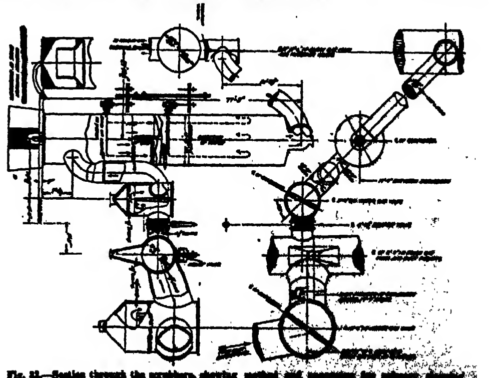

Fig. 32.—Section through the scrubbers, showing method and apparatus for primary cleaning. The cut-off valves are on the side and driven from a vertical shaft.

* Reproduced from *Metallurgical and Chemical Engineering*.

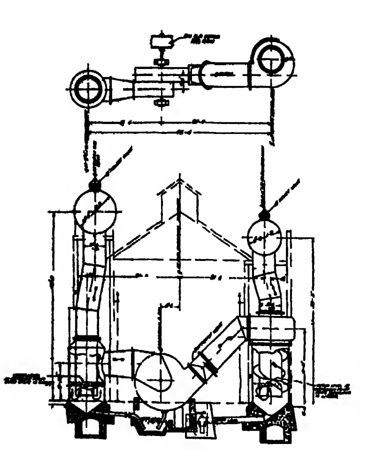

Fig 33.—Section through fans, and method of passing gas through seals and separators.

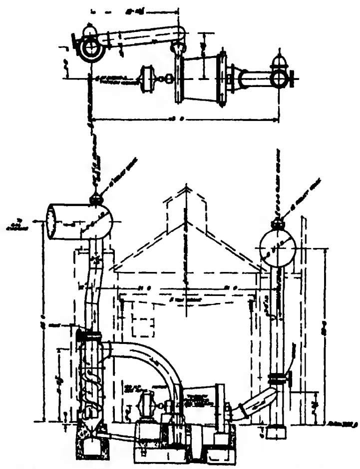

Fig 34.—Section through Theisen's seals and separators showing course taken by the gas.

This attitude is one often censured not only by foreigners, but also by Americans who do not consider all the aspects of such problems particularly the financial one. The relative cheapness of capital and supervision and the costliness of raw materials in Europe as contrasted with the high cost of capital in America and the low cost of raw material constitute in no small measure a justification for the American attitude.

There is reason to hope that a process may soon be developed superior to either the wet processes or bag filtration plant and less complicated and difficult of maintenance. I refer to the Cottrell process for the electrical precipitation of the dust by a high tension direct current passing through the gas column. This process has been developed to complete success in several lines of industry but its sponsors have hesitated to attack the blast furnace problem on account of its size and the complexity of the conditions. If this process shall ever be worked out to a commercial success it will furnish gas absolutely clean with no loss of temperature and with no increase in its moisture. These are the ideal conditions for the use of furnace gas for combustion purposes. For the gas engine it must in any event in present practice be cooled about to atmospheric temperature and this of course can easily be done after the gas is removed by a direct spray. Perhaps the time might even come if hot cleaned gas were available that the gas engine could be adapted to its use and thereby further increase its economy.

In conclusion it may be said that it is impossible at the present time to write a history of gas cleaning. The whole development of the subject in this country covers barely 10 years in all and nine-tenths of it has been in the last 7 or 8 years. The advantages have become manifest and all furnacemen have sought a way rather than *the* way to clean the gas and undoubtedly they were right in this course for the plants installed early even though not the last word of perfection in the subject will have paid for themselves in bettered operating conditions before the much to-be-desired best method is developed. It is possible therefore with this rapid development in progress to give only an outline of the subject and to state briefly the principles which underly its application. To do this has been the attempt of the present article.

Mathematics and Artillery Science

At a recent meeting of the Mathematical Association in London Sir George Greenhill made a remarkable address in which he brought out strongly the relations of science to war and particularly emphasized the almost hopeless position of a country that is supinely content with the systems of a century ago. America might learn a useful lesson from the following abstract of the address derived from the London *Times*.

Sir George Greenhill said that less than six months ago the artillery officer would have said there was no such thing as mathematics in artillery science. But that outlook was now ancient history. This was a mathematical war. Drawing upon his experience as a professor of artillery theory for instances where science could prove itself useful on service, he explained how particulars of the enemy's guns could be deduced from fragments of the wall of a shell and photographic pictures. From a fragment they could determine whether a shell came from one of the 42-centimeter howitzers, the very existence of which still appeared in doubt. Dealing with the calculation for ascertaining how far men should stand from a gun to avoid the danger of permanent deafness, he said they need not fear to stand twelve yards behind the 42-centimeter howitzer and so the story was discounted of the firing party taking cover 200 to 300 meters away when this howitzer was fired. An application of the theory of the conduction of heat would have reassured our men that life in the trenches would not be too cold, or would at least be warmer than in the open, provided only the floor could be drained dry under foot. It had also to be borne in mind that the trench gave better cover than a tent.

Five years ago he had an invitation to Berlin, to visit the Military Technical Academy there. It was a magnificent establishment, such as we could not afford, as our [illegible] thought fit in his department no money was spared in recent equipment including a bomb-proof range available for artillery fire and yet in the heart of a big city. There were plenty of outdoor artillery ranges also to visit, where instructive work was in progress. The Jerry system of education was adopted in Berlin. After a lecture on wire less telegraphy the class was set to work as he saw in making the antennae which had played such an important part in the war. Sixty officers were under instruction at a time for a course of three years, and he was assured their zeal was admirable. It was considered such bad form not to give the best in return for the honor and glory of the Fatherland. But our Regular was apathetic by comparison. We must put our trust in the junior ranks to push old Apathy from his stool and carry us through this war.

Mournful Contrast at Woolwich

It was a mournful contrast to revert to Woolwich, shabby and undisciplined. There they had been evicted from their proper home, and were told to found a new artillery college with the choice of a cellar under some stables or a kitchen and scullery and bare walls in a deserted hospital, there to organize victory and at no expense. With the courage of an Austrian general compelled to maintain his muzzle-loading musket a match for the Prussian needle-gun, the Military Director assured them that there was nothing superior to be found at Greenwich, in the Naval College there lodged in the old Palace. Such dismal, penurious surroundings had a disastrous effect on the *genius loci*, and they never really recovered from a downhearted spirit not calculated for victory. Our military science was under the rule of Thumb, the official genius. His fumbling method was considered a match for disciplined theory.

We saw already how the cost had been well laid out in this war of the Berlin Military Technical Academy, the German jumping off with a lead he was able to keep up for [illegible] The finished article of the academy was employed in the dissemination of true theory and in the scientific direction of warlike preparation as at Krupps. Assuming everything for the best for the Allies and if we lived to go in again at Antwerp an interesting match would be watched between our artillery science and the German to see how long it would take us to get the other side out compared with our own innings and the time we kept our wicket up. No long range fire, he had been assured, was ever going to be of any use again involving theoretical calculation. The word was "Gallop up close to 400 yards and let them have it."

The country was furious at the way our poor fellows were pounded mercilessly at the start by long range accurate howitzer fire with no protection from our own side. King George's stirring appeal "Wake up England," was intercepted by our rulers, and it was England the unready again when our senior lethargy bumped into the titanic energy of the German Empire.

Light, Power and Irrigation in California[1]

Hydro-electric plants have reached a high state of development in California. At present there are 110 reservoirs with a storage capacity estimated at 235 780 000 000 gallons and the plants served produce a million horse-power in electric current which is used for light and for power not only for running car lines but in factories as well. In many cases the current has to be carried great distances from the generating plants to the place where it is used and as high as 150 000 volts are carried on some of the lines. One most useful feature that has been developed in planning some of the California plants is the utilization of the water after it has done its work in producing electricity for irrigation and where this cannot be done directly it has in some cases been found feasible to use electric power to pump water for irrigating what would otherwise be unproductive lands.

NEW BOOKS, ETC.

SMITHSONIAN PHYSICAL TABLES. Sixth Revised Edition. Prepared by Frederick E. Fowle, Aid Smithsonian Astrophysical Observatory. Washington: The Smithsonian Institution, 1914. Price, $2.

We greet with pleasure a new edition of this invaluable collection of tables. The meteorological tables first issued by the Institution in 1852, and primarily compiled to meet the needs of meteorological observers, received such a cordial acceptance at the hands of physicists in general that the volume was followed by three others, dealing respectively with geographical, physical, and mathematical tables. Each of these books presents independently the latest knowledge in its particular field, and together they form a homogeneous series. The fifth and sixth revisions of the physical tables gave opportunity for the consideration and inclusion of much new data, and many governmental and other authorities have contributed to the improvement of the work. The tables have been very carefully rechecked, typographical errors eliminated, certain tables amplified, and not a few entirely new tables added. To Roentgen rays and to radio-activity entirely adequate space has been accorded. All the usual compilations presenting logarithms, strength of materials, compressibility of gases, liquids and solids, sound velocities, and terrestrial magnetism, are of course to be found, and with these a wealth of calculation relating to subjects in less frequent use, such as musical scales, aerodynamics, light-efficiencies, explosives, and magneto-optic rotation. Every physicist should hold this as one of the most useful volumes of his working library.

THE YOUNG MAN'S CHANCES IN SOUTH AND CENTRAL AMERICA. A Study of Opportunity. By William A. Reid. Washington: Southern Commercial Congress, 1914. 12mo.; 173 pp.

A most timely and vital discussion is this study of present-day opportunity in the logical field of our future activities. It is endorsed in a few words of sincere appreciation by John Barrett, director general of the Pan-American Union, with whose staff the author has held an important position for some years. There has been a dearth of just such intimate information as is conveyed by his thoughtful papers, and our young men of worthy ambitions to whom the papers are addressed may learn from them not only of Latin-American opportunities, but also—what is of almost equal importance—of the pitfalls to be avoided. It is pointed out that to take advantage of Latin-American needs it is not always necessary to reside in South America. Periodical travel and a careful study of requirements will often serve quite as well. Mr. Reid discusses positions and openings in agricultural, engineering, and commercial enterprises, presents factors in development as recognized by competent authorities, tells us what the Latins say of themselves, and gives the names of many firms employing North Americans. To youthful, strong and progressive spirits whose eyes are turned southward this series of studies may be followed to great advantage.

STUDIES OF TREES. By J. J. Levison, Forester to the Department of Parks, Brooklyn, N. Y. 8vo.; x, 253 pp.; 155 text figures and half-tone plates. New York: John Wiley & Sons, 1914. Price, $1.60.

This book is intended for the use of the teacher of nature studies and the student of elementary forestry. Although there are several other excellent popular works which deal with this same general theme, Mr. Levison's book is much needed and will be eagerly welcomed by many who are interested in the identification, structure, habits, and uses of our most common trees. The book is divided into nine chapters dealing with identification of trees; their nature, habits and growth, insects and diseases which attack them; their grouping and planting; the pruning and care of trees; the characteristics of the commercial woods; the care of the wood lot, and a general consideration of the study of forestry in its many aspects. In the identification of trees, for instance, stress is laid on some one character that stands out prominently and distinguishes the tree at a glance from all others and in all seasons of the year. Possible confusion with other trees of similar appearance is prevented through careful comparisons which bring out the peculiarities of each species. In these respects the book is unique and is different from any other now available. The discussion of the planting and proper care of trees and of the fundamental principles of forestry, based upon the author's experience of over eight years in the Department of Parks, Brooklyn, N. Y., and in the United States Forest Service, is thoroughly up-to-date and reliable, and will be found suggestive and usable in the highest degree. It is especially recommended as meeting the needs of farmers and others having the care of estates and woodlands, and of students in short or elementary courses in agriculture and forestry. The treatment is concise, systematic and free from an undue use of botanical terms. The author's aim throughout is to give only the salient points and to so present his text that the reader is enabled to reach at a glance, the main features of the subject under discussion. While this book is intended to offer a general and elementary *résumé* of the whole subject of tree studies and will probably be read chiefly by teachers interested in nature work in schools, nevertheless its readable style, choice and arrangement of subject and emphasis laid upon accuracy, cannot fail to commend the publication to trained foresters and others.

ECONOMICS OF EFFICIENCY. By Norris A. Brisco, A.M., Ph.D. New York: The Macmillan Company, 1914. 12mo.; 385 pp. Price, $1.50 net.

The literature of the new efficiency grows by leaps and bounds. Defining the aim of the new era as the elimination of waste, Prof. Brisco sets forth the latest knowledge pertaining to the reduction of expenditure in energy, time and materials. The underlying principles are exposed, their importance demonstrated, and their operation simply explained for the benefit of the business man. Organization and coordination in the industrial world is considered from different standpoints. Methods of handling men are debated upon, and the hiring of labor—a science too frequently neglected—is the subject of some sensible suggestions. The policy of receiving applicants only when a vacancy occurs is strongly condemned. Habits, fatigue, training and environment, all come within the scope of the work. The chapter on wages and wage systems will be enlightening to many employers hitherto content to jog along the beaten track. Test questions and bibliographies give the work a text-book value.

ELECTRIC-LIGHT FITTING. A Treatise on Wiring for Lighting, Heating and Other Domestic Uses to which Electricity can be Applied, and the Laying Down of Small Private Installations. By S. C. Batstone, A.M.I.E.E. New York: The Macmillan Company, 1914. 12mo.; 317 pp.; 238 illustrations. Price, $1.50 net.

Here is one of the most attractive presentations of the subject we have seen. The laws and the units of measurement are very clearly explained by means of simple analogies. The various accessories of lighting are before us in the clear line drawings of the book, and their aid is continued into the layout of circuits, house wiring, and the equipment of complete private plants. The text is concluded with the rules laid down by the Institution of Electrical Engineers, which were framed with a view to satisfactory results in the use of low-pressure energy not exceeding 250 volts.

RESISTANCE OF MATERIALS. By S. E. Slocum, B.E., Ph.D. New York: Ginn & Co., 1914. 8vo.; 210 pp.; illustrated. Price, $2.

A noticeable feature of this text is the employment of the principle of moments to the exclusion of calculus processes. This, of course, means simplicity in exposition. The necessity to await the completion of a course in the calculus is obviated, and the student is enabled to enter upon the mechanism of materials at an early stage. In trade schools which omit the calculus this advantage will be at once apparent. Principles and practice have been so skillfully interwoven that their knowledge is simultaneously acquired. Engineering applications supplement the text, and answers to problems are bound with the book.

THE WAR AND AMERICA. By Hugo Munsterberg. New York and London: D. Appleton & Co., 1914. 12mo.; 210 pp. Price, $1 net.

Anything from the pen of Hugo Munsterberg is illuminating and of great interest; and although many of the American readers of this work will not subscribe to some of its sentiments, they will find it well worthy of purchase and careful reading. The work discusses the essential factors and issues in the European war and their meaning and import for America. The author believes that the hour for an impersonal account of the war has certainly not yet come and may not come for a long while; and that what our time can contribute is the reflection of the great war in the minds of individuals. Since Prof. Munsterberg's life has brought him into close contact with much which is essential to this war, he believes that this study may help toward a better understanding of facts and feelings which are easily misunderstood in America. "Whatever more the struggle may bring," says the author, "refers to outer events, to the harvest of the guns, to victory or defeat. It cannot change the issues with which these pages have to do. They do not speak of soldiers and strategy and the chances of the battlefield, they speak of right and wrong, they speak of eternal values." The general drift of the book may be determined from the heading of the chapters, the first of which is entitled "The Aggressor." Following this are chapters on "The Anti-German Sentiment," "The German-American," "Threatened Provinces," "The English," "Philosophers," "The Russians," "The German Policy," "The Kaiser," "The Silent Voices," "The Americans," and "The Morals of the War."

THE WAR IN EUROPE. By Albert Bushnell Hart, Professor of the Science of Government, Harvard University. New York and London: D. Appleton & Co., 1914. 12mo.; 254 pp. Price, $1 net.

Prof. Hart has written this book in the belief that other Americans besides himself might be interested in a brief but systematic statement of the resources, aims and difficulties of the European powers; the manner in which they became involved in the war; and the probable result of the struggle to America and to the rest of the world. The work is based on personal acquaintance with all the countries at war except Russia and the Scandinavian countries. Much of the matter results from studies begun 20 years ago in the universities of Freiburg and Berlin and the Ecole des Sciences Politiques in Paris. The book is intended to be a study of facts, conditions and probable results, and is not intended as an argument. The notable chapters in this volume are those on "The Significance of the European War," "The Six Great Powers," "International Rivalries and Strains," two chapters describing the war in the Balkans and how that war became European, "The Psychology of the War," and the effect of the war on the United States and its probable outcome.

THE WELLCOME PHOTOGRAPHIC EXPOSURE RECORD AND DIARY. U.S.A. Edition. New York: Burroughs Wellcome & Co., 1914. 281 pp.; illustrated. Price, 50 cents.

The Wellcome Diary for 1915 comes to us in the same attractive makeup that has become familiar to us. As a reference and note book for the photographer it has many features to commend it. The sliding-scale exposure calculator attached to the inside back cover is, of course, in evidence as usual. Timely hints and useful tables abound. There has even been found room for a frontispiece in color—a blue hyacinth—which is an exceptionally charming bit of work.

MOTOR-CYCLE PRINCIPLES AND THE LIGHT CAR. By Roger B. Whitman. New York: D. Appleton & Co., 1914. 12mo.; 281 pp.; illustrated. Price, $1.50 net.

Many readers have a grateful recollection of Mr. Whitman's "Motor Car Principles." In this later volume he takes up the timely subject of the motor-cycle and the light car, stating very clearly the essential differences between the latter and the standard type of automobile, and analyzing in detail a representative light car. Motor-cycle engines and their accessories are very thoroughly covered, with gearing practice, cooling, lubrication, carburetion and ignition. Construction details of the different types are not gone into, the author taking it for granted that, once principles are well understood, their application to variant types is an easy matter. The chapters on care, maintenance, and the causes of trouble are illuminating and full of practical help, and the work is worthy of warm appreciation from any interested in either of the motor vehicles with which it deals.

OPTIC PROJECTION. By Simon Henry Gage and Henry Phelps Gage, Ph.D., Ithaca, N. Y.: Comstock Publishing Company, 1914. 8vo.; 731 pp.; illustrated with plates and with more than 400 text-figures. Price, $3.

Here we have a science that has lately made such strides in popular appeal, and which promises as much in the educational field by its graphic impartation of knowledge to a large number of persons at one time, that such a broad and yet explicit work as "Optic Projection" should immediately find a wide circle of students. All kinds of projection apparatus and all methods of lighting are presented. The magic lantern, opaque projection, and the preparation of slides are most fully dealt with. The projection microscope, drawing and photography by means of lantern and camera, and moving pictures, are all explained by the profusely illustrated text. There are chapters on the room and the screen, electric currents and their measurements, the optics of projection, and the use of projection in physics. In a word, apparatus of various forms and using various methods of lighting, are considered from the standpoint of the operator, the manufacturer, and the student. Certain faults in present-day manufacturing practice are pointed out, and remedies suggested.

FUNDAMENTALS OF PLANT BREEDING. By John M. Coulter, Ph.D. New York: D. Appleton & Co., 1914. 12mo.; 347 pp.; illustrated. Price, $1.50 net.

The increase of population in excess of food production creates a problem that becomes more and more insistent with the passing of the years. Science is gradually acquiring a knowledge that makes possible a revolution in plant culture. The author of the volume in hand presents and summarizes this knowledge in intelligible language. From theories of natural selection and mutation he passes to a consideration of reproduction and culture, reviewing recent work in genetics and explaining the role of hybrids. The securing of drouth-resistance and of disease-resistance is studied. Forestry and its methods is adequately dealt with, and there is a short account of what the Government is doing for agriculture in general. The soil in its relation to plants is a most important consideration, and this is reserved for the final chapter. Altogether the work is very timely and acceptable, and presents its subject in a capable manner and from a positive point of view.

AUTOMATIC TELEPHONY. A Comprehensive Treatise on Automatic and Semi-Automatic Systems. By Arthur Bessey Smith, E.E., and Wilson Lee Campbell, E.E. New York: McGraw-Hill Book Company, Inc., 1914. 8vo.; 407 pp.; illustrated. Price, $4 net.

As a subject that is receiving much attention, and toward which much experimental work is being directed, automatic telephony is rapidly building up a literature of its own. Automatic or semi-automatic systems have already been adopted by many governments and as a natural consequence there is an increased demand among telephone engineers for a wider and deeper knowledge of its principles and practice. The treatise in hand endeavors to meet this demand by describing typical circuits and [illegible] more important systems now in use. [illegible] the distributor installation, are diagrams that indicate the comprehensive nature of the work. The systems of the larger American companies are clearly described, and a final chapter on development studies will prove especially useful and suggestive to students. The many diagrams and inserts lend clarity to what is a somewhat intricate subject.

LUNDBERG LIGHTING CONNECTIONS. With Introductory and Explanatory Notes by W. Perren Maycock, M.I.E.E. London, England: A. P. Lundberg & Sons. Price, 7d.

"Lundberg Lighting Connections" is a vest-pocket booklet describing modern tumbler-switch controls. Numerous diagrams and concise explanations abound. Single-switch control is designated as a survival of the "bad old days of [illegible]," and combination installations are urged.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, FEBRUARY 27, 1915

Charles Allen Munn, President
Frederick Converse Beach, Secretary
Orson D. Munn, Treasurer
All at 361 Broadway, New York

Entered at the Post Office of New York, N. Y.
As Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year	. . . .	$5.00
Scientific American (est. 1845) "	. . . . .	3.00
American Homes and Gardens "	. . . . .	3.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check

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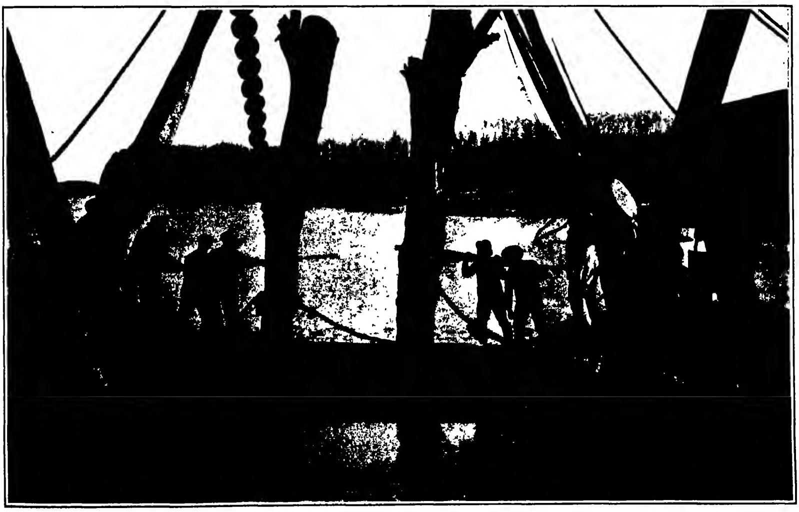
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX] NUMBER 2044]

NEW YORK, MARCH 6, 1915

[10 CENTS A COPY $5.00 A YEAR

Hauling out a tree stump by a lifting derrick.



Sawing snags into sections as they are lifted from the water.

HOW THE GOVERNMENT KEEPS OUR RIVERS FREE FROM OBSTRUCTIONS.—[See page 149.]

Personal Biologic Examinations*

The Condition of Adequate Medical and Scientific Conduct of Life

By George M. Gould, M.D.

THE merchant has his annual round-up: the merchant his yearly account of stock and balancing of books, the machinist gives his engine a thorough going-over at regular intervals; every military organization has its reviews and inspections, every government its budgets—indeed, every financial hair of the commercial head is noted, and not a sparrow of the hunter, Success, falls to the ground unnumbered; those that do not fall are even more accurately numbered. But it is not so concerning the one piece of mechanism that conditions all these things, and that is the most valuable of all earthly possessions—the human body. For all practical consideration a man's body is his life, and yet civilization has come so far without any systematization of the business and mechanics of the entire single and personal life. The science of bodily living in its complete extent still awaits its discoverer. Numberless philosophers treating of the conduct of life have soared in superficial inexactness and easy generality over the heads and hungers of the individual liver, but they have utterly failed to formulate the physiologic and pathologic conditions of success and failure. All the biologic and medical special sciences have struggled toward an unreached unity; all are simple rays, as it were, awaiting the lens of a focalizing intelligence to illumine the concrete image of our total physical appearance here. War has devised a rough and crude system of physical examinations for the would-be soldier; insurance companies have more accurately examined the bodies and life-prospects of their policy-holders to estimate their financial risks; through the Bertillon system, criminology has still more perfectly fixed the anatomic measuring of the bodies of the law-breakers; the Amherst and Harvard examinations have looked into the muscular functions of a few students for four years of their lives; the psychophysic laboratory has measured a few neurologic reactions; the medical practitioner has found out a few ways of reaching backward to the etiology of some single diseases; a few hundred school children have been subjected to some tests as to growth and the influence upon organization of poverty and wealth. But all these, I believe, are sporadic and ineffectual hints of a coming science of man, based upon a thorough-going and repetitive system of physiologic and pathologic examinations which will ultimately give us a genuine and all-comprising science of anthropology based upon all the data, morphologic, physiologic, and pathogenic, of the entire individual life. Prophecy and prognosis are based upon a thorough knowledge of the past and present fact, a right understanding in a scientific sense of the evolution of the organism and of its present departures from a normal standard. For his children a foresighted man must wish such an accounting, such a prophecy and prognosis; and as to himself every intelligent adult, when he awakens in scientific consciousness, must try to look forward through the years, and reckon up his powers and possibilities of life. This most important function of prevision has heretofore been left to the gypsies, the palmists, the astrologists, and the clairvoyants! Is it a wise way for science to leave the individual struggler, unconscious and ignorant of his own body and its fateful laws, incapable of learning the scattered and unullified half-sciences blindly converging to some far-off unity of mutual helpfulness and life? The crowning work of scientists is to turn science into prescience. The unification of the sciences dealing with the conduct of life; the making practical and useful our knowledge of the individual organism; and lastly to establish a scientific prescience—such are the ideals of a living anthropology.

Is it not at once plain that these ideals can be realized only by a system of periodic examinations and records made every year or every five years, throughout the life of the individual organism? Such a system of records may be held generally to comprise the following elements:

1. *The Hereditary Datum.*—The endowment at birth, the influence of heredity, must in every way govern and condition the development of the organism, and modify every reaction to environment. It is wise, therefore, in all ways possible to fix, at the opening of life, what is this datum of inheritance. Nationality, ancestral and genealogic histories, craniology, cerebrology, etc., help to make up the estimate of this one factor.

2. *The Development and Historic Record.*—Especially during the period of growth—childhood and adolescence—should the space between the annual or quinquennial systematic examinations be historically epitomized. The strains, work, illness, and tasks conquered or incomplete, are surely a necessary part of the life-chronicle.

3. *The Morphologic or Anthropometric Examination is Fundamental.*—In this the Bertillon system, modified, perfected, and expanded, or something similar, should form the basis of such a system of physical measurements, descriptions, and records, statistic and graphic, that any future variation of the organism would be detected in later examinations; and thus would be preserved the morphologic picture of the individual for the whole life.

4. *The Physiologic Record* would include the testing and tabulation of all the significant reactions and functions. These would be made up of all necessary dynamic tests of the muscular system; of statements of accurately observed metabolic and nutritional functions; the reactions and reflexes of each of the special senses, and of those of the neurologic and psychophysic systems. The profound influence of habits, both positive and negative, innocent or harmful, should also be remembered.

5. *The Psychic or Intellectual Datum* is one too carelessly ignored in scientific and anthropologic studies. The fundamental qualities of character, disposition, memory, sentiment, religion, reason, morality, education, etc., are powerful influences acting upon and reacting to the environment and to disease, and if they are left out of the count a most valuable determinant of scientific prescience is lost.

6. *The Pathologic Element* is one heretofore almost or utterly ignored in anthropologic studies, and in instructions as to the conduct of life. The profession should urge its profound importance. The examinations at stated periods should in large part consist of the records of the findings of expert medical specialists secured by all the arts and instruments of diagnosis at their command. All departures from health and normality that indicate pathologic results or tendencies in any organ, or in the organism as a whole, are absolute conditions of estimate as to present powers or prospects. One is almost inclined to think that the savings in medicolegal cases, by such a system of examinations, would defray the expenses of making them. Some time ago a railway company, after several years of legal proceedings, was forced to pay a man $10,000 damages for intracranial hemorrhage said to have been caused by a fall from a car. When the man died there was found in his brain a bullet which had been received 25 years previously in the Franco-Prussian war, and this had produced all the non-feigned symptoms for which the railway had to pay.

7. *The Factor of Heredity* closes the circle, with the possibility of making more accurate the knowledge of the transmission of the individual endowment to the child. Successive generations are but the completion and extension of a single personality. The family is the realization of the incomplete individual.

Leaving out of consideration the questions of the onerousness of the task proposed, and the apparent impossibility of carrying out so many observations, one may ask as to the feasibility of keeping the records of such a series. The answer to this query points to the most remarkable plasticity and adaptability of the modern plan of record-making by the card system, with its ever variable and extensible use of loose leaflets or cards of different colors, numbers, ear-marks, sizes, etc. Photography, the kromscop, the phonograph, the instruments of the physiologic and psychophysic laboratories, and those of every specialist in medicine, make it easily possible to condense the chronicles of all tests and examinations in an inexpensive and effective way. The post-mortem records, and the preservation of the brains, and, perhaps, of the skulls of the subjects, would supplement the work.

As has been intimated, we already have the beginnings, the sporadic attempts, and detached parts of such a system of examinations. The Bertillon criminal records of the police bureaus, the anthropometric data of military examinations, the results of athletic and gymnasium tests, those of psychophysic laboratories, the medical examinations of school children, and those especially of life insurance companies, etc.—all these indicate the thought, labor and expense which civilization is giving to the problem. But the most important of all contributions might be the case-books, hospital records, and patients' histories of physicians. Hardly a tithe of the precious material, however, is utilized. The waste of biologic data—wasted because not systematized and unified—in the lost records of physicians is appalling. The most valuable books in the world are the oldest city directories, scientific statistic records, etc., and more valuable still would in future years be the present day case books of scientific physicians, if they were well kept and illuminated by statistical and scientific judgment. We now dump them into the pulp-mill.

Is it a foolish dream, is it an unrealizable ideal, that all these things might be preserved, and rendered of use to science and humanity by some institution carried on by the Government, by a university, or by a union of scientific and medical men, whereby the records of individual lives might be made so frequently, so continuously, and so scientifically that we should at least gather the inductive data for a genuine science of anthropology, pathology, and ethical biology? If governments could be prevailed upon to devote to this work one tenth the money now squandered in war; if legislators could be prevailed upon to give to it a small proportion of their stealings and political plunderings; if a fraction of the money poured into the pockets of the ward and city bosses could be got; if a small percentage of that spent on comic opera could be shunted this way! If these are idle dreamings is it not perfectly possible that in future ages some wise legislator of some civilized government may convince his fellows that not only is this the duty of the national administration, but that the very beginnings of the system are already in operation in the national census-taking? In this the mechanism is really inaugurated, and needs but the inclusion of the civil service examination, the soldiers' entrance tests, and the governmental pensioners' medical examinations, to bring it a long way toward perfection. With the plan once determined upon, and the brain once found to gather the haphazard and discrete parts to an organic unity, but little additional expense would be incurred over that now spent in the separate systems. Indeed, the scheme itself is only an extended and a perfected bureau of vital statistics. Once such co-operation were started, the city and State with their criminologic statistics, the insurance companies with their accurate vital and pathologic records, and especially the medical profession with its systematized records of individual and social morbidity, and many other agencies, would be drawn into co-operation, and the bases of a truly inductive and physiologic science of civilization would begin to be laid.

While we wait for that millennial palace of science we physicians need not be idle—nay, we may be at work in the quarries. Our first duty is to reorganize, systematize, and make scientific our case-books and recordings of patients' histories. Let us study this great and neglected art so that these most precious fruits of our life work shall not end in the pulp mill. The lack of literary workmanship in making and keeping our records of disease is altogether deplorable. What is left to science of the life work of a million physicians whose business has been with the most precious biologic facts of the world? Can we not perfect some bridge whereby the results of our life labors can be carried over the stream of death and become the property of general biologic and pathologic science?

Surely then, our second duty is to make our science prescient, by means of the repeated examination at stated intervals of those patients whom we can convince of the necessity and wisdom of such a proceeding. It is a shame of medicine that in the one department of our science which we are most foolishly inclined to look down on with too much superciliousness, its practitioners have outrun us. The dentists have long recognized the need of periodic examinations of the special organ, regardless of symptoms, and they have at last driven the knowledge into the minds of their patients. Thousands of patients have their teeth periodically examined for beginning needs and diseases or to prevent them. If this be wise as regards the teeth, how infinitely wiser it would be as regards the kidneys, the eyes, the heart, arteries, etc., and the person as a whole. It is the shame of medicine and the basis of quackery, this symptom treating and symptom killing. What a horrible fact—this of the vogue of the pain deadeners! Millions of dollars are capitalized in the business, and half or three fourths of the work of

*Presented to the Section on Practice of Medicine, at the fifty-first annual meeting of the American Medical Association, held at Atlantic City, N. J., June 5th to 8th, 1900, and published in the Journal of the American Medical Association, July 21st, 1900.

our lives is devoted to the mere stopping or deadening of symptoms. But, as we all know, true medicine is to stop the cause of symptoms, to prevent the symptoms from ever arising. For many years in my specialty, I have been begging that biennial ocular examinations should be made, regardless of "no trouble," regardless of "perfect satisfaction." Absence of symptoms is no evidence whatever of absence of disease. No eye should ever be left over two years without re-examination. No spectacles can remain correct two years, because no eye ever preserves the same refraction, balance, and powers, for that period of time.

And what good also is the enucleated eyeball, or any piece of dead tissue, in the hands of the pathologist? Certainly only to prevent other living eyes and organs from becoming as these dead ones have. True pathology is surely knowledge of the disease in the making. The pathologist's final problem is to prevent pathologic specimens from ever coming into his hands. Qua pathologist he must commit scientific suicide. Most of our fashionable pathology is the paleontology, not the biology, of disease; but was it not said of old, that it is better to be a living dog than a dead lion? How is disease in the making ever to be discovered except by examinations, continuous observation, of the living supposably-well organism?

Is it not even true of living disease that one half the patients seen by the doctor are seen far too late? For paresis, locomotor ataxia, etc., and for many psychic diseases we do nothing, because we recognize their existence so late that nothing can be done. Had they been seen earlier injury could have been prevented. Surely in more than 25 per cent of my patients many years or whole lifetimes of suffering and disease could have been obviated. It is doubtless true in general medicine. All good medicine inevitably tends to become preventive medicine; all good physicians labor to stop disease before it arrives. The whole ingenuity of the trained diagnostician is now expended on the problem of the earlier symptom. He is the greatest discoverer who finds the presymptom, or the symptom of the symptom; the greatest therapeutist is he who cures before the disease exists, he who starves the bacillus to death, he who stops the evil habit, thus preventing the malfunction that becomes organic disease. The best cat is the one that kills the rat that eats the malt that lies in the house that Jack built. It is a truism that gout exists in the patient's system long before it causes a twinge of pain; the kidneys are ruined before the slightest subjective system is manifest; there may be heart changes indicating the existence of nephritis, which a single uranalysis may not detect; arteriosclerosis may be present prior to subjective symptoms, and the objective examination would detect it; there may be unsuspected diabetes without symptoms until examination of the urine reveals it—even with our crude prescience early uranalysis of the apparently well would often reveal the hidden evil at work sapping and mining toward the vital centers. Every oculist has often discovered albuminuria before the general physician suspected it. There are a hundred known intimations and auras of oncoming disease, but there are a thousand undiscovered ones, presymptoms, advance scouts and forerunners, to be learned when the slight and unconscious departures from normality are studied by examinations of the supposedly well. Pathogenesis, not therapeutics, is the ultimate study of all medicine. And all pathogenesis is by no means running bugs to their holes: the greater number of life wasting diseases are not bacterial in origin; and even the growth of the bacterial diseases depends on the soil in which they are sown.

I picture to myself a new field of work opening out before the poor plundered general practitioner. It must often seem to him that as a general he has been stripped of both army and enemy. One by one the specialists have robbed him until he has left hardly a soldier or a patient. The surgeon first took almost half of his army, and now threatens to relieve him of Colonels Appendicitis and Typhoid, and heaven knows of how many more officers which he formerly considered his very own. Then the aurist, the oculist, and the rhinologist deprived him of his special senses, and the laryngologist rendered him aphonic. If the obstetrician and gynecologist left him one or two of all his women folk, the rest cure man and the neurologist soon alienated the affections of these hysterics—and they lived unhappily ever after. The pediatrist stole his babies and the psychiatrist his mind; and, lastly, the gastrologist will not allow him to have all to himself even a simple stomach ache.

The truth seems to be that of all the specialists the generalist has been squeezed into the narrowest specialty, and the surgeon is grasping avidly at his one or two remaining conducts. Even the diseases of the lungs, stomach, and kidneys are now claimed and we may soon expect to see such advertisements in the religious and daily newspapers as: "A new operation for neurasthenia; craniotomy for unselfishness; preventive inoculations in case of threatened breach of promise; vaccinations for antivivisectionists; damaged heart-valves surgically repaired while you wait; kidneys transplanted immediately following the next electrocution; complete maturation of the artificially fertilized ovum in our new twenty-first century incubator."

The family physician's function seems to be fast becoming that of adviser-in-general and referrer-to-others; the "last straw" is that ethics will not permit these others to divide their fees with him. Nothing in fact is left to him except to have permanent anorexia and to move to a climate in which house and clothing are not necessary—Porto Rico and the Philippines, for example—providentially supplied, without doubt, for this and similar tariff purposes.

But seriously, have we not gone too far with our specialism, and are we not thereby in danger of losing the co-ordinating sense and oversight of the organism as a whole? The specialist cannot be dispensed with. By his aid and through his accuracy medicine must progress; but neither should the generalist be squeezed aside. He is even more necessary. It is his duty to teach his under officers, the specialists, their proper places, and by his sane and large grasp of all the facts supplied by these subalterns, by his co-ordination of the work of each and of all with his own overlook of organism and life as a whole, he brings cosmos out of chaos, and organic unity out of hundred-eyed and selfish diversity. The specialist is fatally inclined to treat the disease; to the generalist must be left the far more important treatment of the patient.

It may seem hard and impertinent to say to an audience of generalists that the generalists have been robbed because of their own fault and negligence. The so-called stealings of the specialists are in reality helpful and if rightly understood they leave the generalist his proper work. Life, it has been said, is made up of little things; and yet life itself is not a little thing. So it is with health, fullness of years, and utilization of powers; they all depend, medically and physiologically, upon little things, and yet compositely they are "the greatest thing in the world." In the vogue of the specialist, the generalist is more than ever needed. If the aristocrats have usurped power, there is the chance and demand for a powerful king. The specialists are, or may be made, the assistants of the general physician, who needs their help and all the data they can supply, and whose supreme function it is to fuse the whole to a higher unity and to establish the secret relations in reality existing in all. There is no specialist who is not willing and glad to make full and systematic reports to the general physician of all his findings. It is his duty to the patient and it is the specialist's self-interest to do it well. He is not so stupid as to offend the referrer of patients. In this function the generalist has the whip-hand—and he should use it, at times.

And thus it happens that the desirable system of personal biologic tests sketched need not await the action of government, the university department, the city or State institute, the union of anthropologic societies, or the anthropometric and pathologic institution founded by private endowment. Let us earnestly pray and work for any or all these things; but in the meantime much may be done by medical men and societies to prepare for the larger and more perfect outworking of the scheme—nay much may be done toward the realization of its more distinctively medical features.

Based upon the fact actually felt by every physician, that a series of systematized periodic examinations of patients apparently well would often reveal beginning diseases, prevent future illnesses and increase the vital values of life, every one can prevail upon certain patients, students or members of his family, to undergo the necessary tests. The more intellectual and well-to-do citizens will soon realize the self-evident value of such work, and not only submit to it for themselves and children, but will be willing to pay an annual fee for the service. Specialists will be willing to contribute their results. The examinations need be only of the more fundamental and simple factors at first until the good-will, machinery, funds, and recognition of the significance and usefulness of the work grow.

In several ways these examinations themselves are the means of a striking self-education of the physician:

1. In systematizing and perfecting a method of record-keeping there is a subjectively psychologic as well as an objectively scientific result of inestimable good. It is a sort of liberal education. To adapt and perfect the card system to this useful end; to summarize the results of all diagnostic methods; to formulate prognoses; to classify and epitomize so that the whole shall look to the personal advantage, as well as toward the progress of preventive medicine; and finally, to dovetail the combined result into general biologic science and to clarify the laws of heredity; all of this is labor worthy of the wisest selfishness and the best intellectuality.

2. In rendering accurate and mathematical all the known and recognized methods of medical testings, there is much to be learned. It is in catching sight of the forerunning indication of disease, the symptom of the symptom, the functional beginnings of organic abnormalism, that a great deal of progress lies. Who, e. g., as yet, measures the blow or stimulus in taking the patellar tendon and other reflexes, with machine-shop accuracy, also the resultant excursion or reaction, chronicling same in his notes, with absolute or approximate precision?

3. In the excursions into the border land, but still closely related, domains of cerebrology, craniology, psychophysics, criminology, sociology, public hygiene, and all the rest—in learning to make these tests, and chronicle the results required in these studies, one enlarges the range of his subjects, broadens his personal and scientific outlook, in a word annexes with justifiable imperialism and expansion, the adjacent territories of his special science Each gives his light, and, as in all beneficence, by giving, each increases his own as well as the general illumination The stars go out but the day dawns.

Cultivation of Living Tissues Outside the Body*

The story of the cultivation of tissues outside of the living body has already lost much of its novelty. Though we can still easily count the time in terms of months rather than years, since the first demonstration of the development in vitro of isolated fragments made up of connective tissue cells, the fact has been established so conclusively and the technic developed so successfully that the cultivation of tissues in this way has already become a familiar practice in many laboratories. It is sometimes said that familiarity breeds contempt; but it may be wholesome at times to renew our acquaintance with the details of well-known scientific procedures and learn their present status. This is particularly desirable in the case of those persons who little realize the persistence and energy, the patience and forethought, which many of the permanent acquisitions of science demand on the part of investigators. We who share the results all too frequently fail to understand the laborious process by which success is attained. In this field the advice once given to an ambitious medical student may be reiterated: "Success is neither luck nor pull, but the longest, toughest job you ever tackled."

Not long ago Carrel[1] of the Rockefeller Institute for Medical Research called attention to the condition of a strain of connective tissue kept outside of the organism in a condition of permanent life. It was derived originally from a piece of heart extirpated from a chick embryo. The fragment pulsated for 104 days, and gave rise to a large number of connective tissue cells which have since multiplied actively. The strain, after having undergone 358 passages, reached the twenty-ninth month of its life in vitro some time ago. It now appears that the proliferating power has in no wise diminished. During the third year of independent life of the connective tissue we are confronted with the remarkable fact that it shows greater activity than at the beginning of that period, and is no longer subject to the influence of time. Carrel remarks that if we exclude accidents, connective tissue cells, like colonies of infusoria, may proliferate indefinitely.

In this connection it is interesting to note some recent results for human tissues reported from the same laboratory. It has been possible, for example, to keep human fetal tissue, derived from fresh cadavers, in a condition of independent life for several generations.[2] This has led to the attempt to cultivate human sarcomatous tissue in the same manner. The first essay in the direction of growing human malignant tumor in vitro was made in 1911 by Carrel and Burrows.[3] The tissues were kept in a condition of survival for a few days, but no real cultures were obtained. Losee and Ebeling[4] have now succeeded in keeping cultures of such tissue in a condition of active life in vitro for several generations. Their method may, therefore, prove of value in the study of the growth of human malignant tumor.

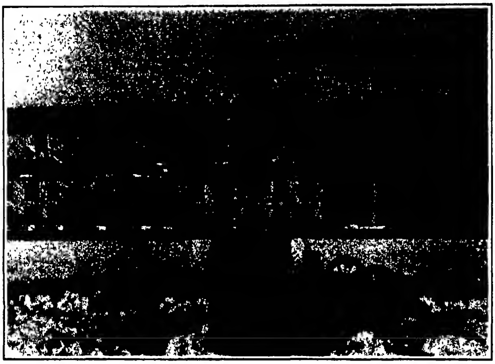
* From the *Journal* of the American Medical Association

[1] Carrel, Alexis: Present Condition of a Strain of Connective Tissue Twenty-eight Months Old, *Jour. Exper. Med.*, 1914, xx, 1; see also *Jour. Exper. Med.*, 1912, xv, 516. Ebeling, A.: *Ibid.*, 1913, xvii, 273. Carrel, Alexis. *Ibid.*, 1913, xviii, 287.

[2] Losee, J. R., and Ebeling, A. H.; *Jour. Exper. Med.*, 1914, xix, 593.

[3] Carrel, Alexis, and Burrows, M. T.: *Jour. Exper. Med.*, 1911, xiii, 387.

[4] Losee, J. R., and Ebeling, A. H.: The Cultivation of Human Sarcomatous Tissue in vitro, *Jour. Exper. Med.*, 1914, xx, 140.



The full-sized experimental flying-boat with hollow V-shaped hull, at Washington Navy Yard.

Experiments With Flying Boat Hulls

By Carl Hawes Butman*[1]

The first report of the sub-committee on hydromechanics in relation to aeronautics just published by the Langley Aerodynamical Laboratory of the Smithsonian Institution, deals with the results of a series of experiments with flying boat hulls. The experiments were conducted at the Model Basin in the Washington navy yard under the direction of Naval Constructor H. C. Richardson, for the purpose of determining the resistance of several models at "displacements corresponding to speeds," on the water, and the resistances "submerged," as a means of approximating their total head resistances in air, and of determining an approximate "coefficient of fineness of form."

The experiments proved particularly successful. A form of improved hull has been derived which will probably supersede the present type of naval hydroaeroplane hulls. This model appears to have certain advantages over the types now in use, possessing less resistance on the surface of the water, and less head resistance in the air under similar conditions.

The model hulls used in the experiment were of the ventilated step type, one-ninth actual size, except one a quarter-size model of the original "Curtiss" pontoon. Plots of the model runs were made by the investigators showing: net resistance, derived effective horse-power, and change of level. The resistance curves were determined by towing the models in the basin at "displacements corresponding to speeds," with a set trim, but free to rise or fall under the influence of suction or planing. The change of level curves show how the planing effect changes the draft at each condition. The models were towed under conditions representing a full load of 2,200 pounds, with the assumption that the get-away occurs at a speed of 45 miles per hour. From the curves it is obvious that suction is present at low speeds, succeeded by a condition in which the model runs hard, followed by a period during which the model begins to plane; just before planing is effected, the slope of the curve lessens rapidly, and when planing is established the resistance falls off sharply with one exception.

A model was designed to obviate the defects of the flat scow-bow type, by introducing the V type bottom for parting the water rather than forcing it aside. An earlier model of the V type caused a great amount of spray, and to overcome this the V section was made full but as this only increased the spray, the V sections were made hollow which brought about the desired results: holding the spray down, increasing the planing effect, and reducing the resistance.

Bow views of five models.

Confirmation of the behavior of the models has been fairly well established by the actual performance of full sized machines. Actual experiments with a full sized machine show that the improved hollowed V section hull is very desirable on account of the good landing qualities.

From the experiments carried on it has been determined that the step should be close to the center of gravity, to eliminate the nosing tendency, to facilitate change of trim while planing and to avoid a change of balance when getting away or landing; hollow V sections decrease the spray, cut the water easier and cleaner, plane better, and reduce the shock of landing or running through rough water, practically eliminating the necessity of shock absorbers. A shallow step seems to be sufficient, but ventilation back of the step is essential to facilitate the breaking of suction effects. The bottom forward of the step should be inclined to the axis of the machine but not so greatly as to cause the machine to plane before the controls are effective. The bottom abaft the step should rise strongly to favor a steepening of the planing bow before the elimination of suction, and to get the tail well clear when planing begins.

Diagrams were also made to show the logarithmic plots of the models when submerged one foot and towed at speeds up to 15 knots. From these plots it is seen that the resistances of the models closely approximate the law of the square of the speeds. The head resistances of the full sized machines were calculated by three methods, and vary about 20 per cent. Several other useful values worked out mathematically.

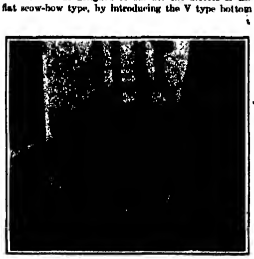
Plans are under way for further experiments on submerged models to determine the stream line flow about the models, as a means of arriving at improvements in form, as well as to calculate the effects of cockpit openings, sponsons, etc., and to study the torque at different angles.

Wheatstone Bridge for Resistance Thermometry

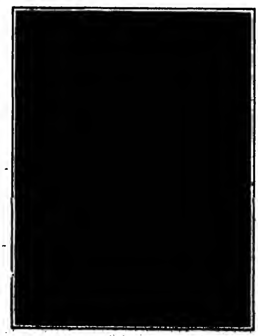
There has just been issued by the Bureau of Standards of the Department of Commerce a paper describing a Wheatstone bridge designed with especial reference to flexibility of use in measurements with resistance thermometers and discussing the use thereof. The bridge is adapted to use with either the Siemens type or Callendar type of resistance thermometer or with the potential terminal type of thermometer by the use of the Thomson double bridge method. The instrument is also arranged so that it may be completely self-calibrated.

The accuracy attainable with the bridge is such that resistances of one ohm or more can be measured to an accuracy of one part in 300,000 in terms of the unit in which the calibration is expressed. This corresponds to an accuracy of about 0.001 degree for measurements with the platinum resistance thermometer. Low resistances, the accuracy of measurement of which is limited by variations in contact resistances, may be measured to about three millionths of an ohm. This figure, rather than the one given above for accuracy, represents the precision attainable in measuring small changes of resistance, such as are usual in resistance thermometry.

Plan views of five models.



Spray made by a model at 8.5 miles per hour.



Side views of five models.

The snag boat "John Macomb" at work on the Mississippi River, showing double bow and numerous lifting derricks.

Front decks of snagboat, showing openings in bow permitting snags to be lifted to a position where they can be sawed into sections.

Snag Boats on Flood Rivers

A Safeguard to Navigation

By Day Allen Willey

MANY of the so-called flood rivers in the South and West, flow through channels where the bottom and sides are merely of earth and sand, and when a river is in flood the current washes out the banks, causing woodland, prairie soil, and other formation to be submerged, and, in some instances the surface of the land, to the depth of several feet is carried down stream by the current in the form of liquid mud.

Such rivers as the Mississippi, the Arkansas and the Red River run through swamp lands in some locations which are covered with trees and bushes. In high water trees are often uprooted and float down with the current. When the flood recedes, the trees may be held in the stream channel, the roots sinking into the bottom and remaining in such a position that they form dangerous obstacles to navigation. Often the upper end is but a few feet below the surface, and a vessel moving in line with it may be pierced through its hull and sunk as the pilot is unaware of the "snag."

Where these washed-out trees project above the water, they are almost as dangerous as the sunken snags, as they are often in eddies and cross currents in the channel where a steamboat may be wrecked against them.

The War Department has adopted several methods to free these navigable rivers of snags. An idea which has recently been adopted is to bore holes in the wood, insert dynamite cartridges, and thus shatter them to pieces. The most effective plan, however, is to pull them out of the water and saw them up, sometimes using the pieces for fuel for heating the furnaces of the boats which pull them out by steam.

These snag boats were the idea of one of the army engineers, and the first was built about 10 years ago for service on the Mississippi river. Since then the boats have been enlarged, equipped with more powerful lifting derricks, operated by a steam engine which is independent of the one which propels the boat.

One of the latest types of these floating snag pullers is stationed on the Mississippi river. It draws less than 4 feet of water, and consequently can be operated on shoals and in other shallow spots. Two engines of a combined capacity of 600 horse-power furnish motive power, giving a speed ranging between 5 miles and 6 miles an hour upstream against a strong current.

The double bows are separated by what is termed a well which is 12 feet in width, each bow being 65 feet in length. At the forward end what is termed a "butting beam" extends from bow to bow. This is a heavy steel beam 22 feet in length, 7 feet wide, and no less than 16 inches thick, greatly strengthening the framework of the boat. As the name implies it is used to ram or butt a snag when necessary to dislodge it from the bottom before pulling it out of the water.

Attached to this beam is a sweep chain which drags beneath the water and is designed to grip the lower portion of the snag and aid in lifting it to the surface. This chain is lowered over the bows by a capstan placed at one end, and raised in the same manner. Its purpose is principally to lift the upper end of the snag high enough to permit the butting beam being pushed under it.

Upon the bows are the lifting derricks, one being utilized to pull out small snags after they have been loosened by the sweep chain and butting beam. Those on the sides are intended to pull up obstructions which can be readily removed by means of block and tackle.

On the boat the crew includes a diver whose duty it is to go under water when necessary to fasten the chain around the trunk, or to bore holes in the wood for the dynamite cartridge and connect its detonator with the wire that extends to the electric keyboard on the boat.

Another large snag boat is in use on the Mississippi and tributary waters which is 187 feet in length, 52 feet beam over the hull, and can operate in water 3½ feet in depth. It is also constructed with a hull of steel and iron, and driven by two oscillating engines, steam being furnished by five 42-inch boilers giving it a total horse-power of about 500. The snagging apparatus consists of two pairs of friction capstans placed in the forward hold and six capstans installed on the deck.

The "Suter" carries a butting beam of oak plated with iron, also a series of five iron shear legs in addition to supporting blocks and tackle, a Sampson chain of 2½-inch links, and a sweep chain.

Such is the capacity of these snag pullers for removing the obstructions to navigation that by the service of this fleet one of the greatest dangers to steamers and barges plying on the flood rivers, has been largely abolished.

Diseases Dangerous at Different Periods of Life

MUCH has been said of late concerning preventable diseases and methods of reducing the annual rate of mortality. The first essential of any such schemes is a carefully prepared summary of the causes of death in a particular country during a specified period, and a statement of the age and sex of those dying within this term of years. For some twenty years the German Empire has published statistical tables of all officially reported causes of death. These have always been divided into periods of life and of late years have distinguished sex. They do not, however, cover the entire population, for the participation of the different states of the empire is voluntary; but there has been a gradual increase until four years ago 96.85 per cent of the inhabitants of the empire were included in these digests. An interesting analysis of the main causes of death at different periods of life, as shown by these tables, is made by Dr. G. Rahts in a recent number of the German journal *Umschau*.

Speaking of infants under one year of age he states that in the decade 1892-1902 the deaths among such infants averaged, during a calendar year, about 20 to 22 of each 100 born alive, and in the five years 1906-1910 only 17 to 18 of each 100. Of late years about 348,000 children die annually in Germany, 332,000 of them dying of known causes. For more than one third of those dying of known causes within the first year the indicated ailment is chronic gastro-enteritis or cholera infantum, that is, the illness arose from unsuitable or defective nourishment. For about one seventh congenital weakness is the stated cause of death, which occurred generally in the first month of life. Other fatal maladies noticeable for their frequency among infants less than a year old were inflammation of the lungs, to which 115 of each 1,000 dying succumbed, and whooping-cough from which about 30 of each 1,000 deaths arose. Tuberculosis, measles, and scarlet fever, taken together, carried off less than 3 in each 100 deaths of young infants, that is, less than whooping-cough alone.

For the period of childhood from the beginning of the second year to the end of the fifteenth year Dr. Rahts finds, in his examination of the tables, that the annual average of deaths was about 111 to 112 per 1,000 living; the annual average during the five years 1906-1910, from which the figures are mainly drawn, was about 140,000 children, of whom 8,300 died of unknown causes. The most important causes of death given for this age per 1,000 children who died are: Pneumonia, 147; other diseases of the respiratory system, 65; tuberculosis, 105; diphtheria (including croup), 92; scarlet fever, 64; measles, 54; whooping, cough, 39; diseases of the digestive tract (including appendicitis and its consequences), 110; accidents, 45.

In discussing the statistics just given, Dr. Rahts says: "According to this in the period from 1 to 15 years life is threatened to a large degree by four widely spread, easily conveyed diseases of childhood, diphtheria, measles, scarlet fever, and whooping-cough, for these four diseases together cause the death of almost the fourth part, 22 per cent exactly, of all who succumb in this period of life. After these, pneumonia, or some other disease of the respiratory system, is designated as the cause of death for fully one fifth, 21.2 per cent of all who die from known causes, and tuberculosis as the cause for fully one tenth. Disease of the digestive tract, including appendicitis, was a somewhat more frequent cause of death than tuberculosis. Lastly, the large number of fatal accidents at this age is noticeable, for about 1 of every 22 cases was attributed to 'death by accident.'"

According to these tables, tuberculosis of the lungs carried off the greater number of those who died in the period between 15 and 30 years of age. During the years 1906-1910 the deaths from this disease were 462 per 1,000 deaths from known causes among women and 375 per 1,000 deaths among men. Other forms of tuberculosis in addition are given as the cause of death for a further 35 per 1,000 deaths. Among those from 15 to 30 years old other forms of disease, as compared with tuberculosis, are much less frequently the cause of death. Among every 1,000 males (females) who died from known causes at this period of life there were: 65 (77) deaths from diseases of the heart or of the blood-vessels; 61 (46) from pneumonia; 33 (37) from other diseases of the respiratory system; 51 (54) from diseases of the digestive tract, including appendicitis.

In continuing his analysis Dr. Rahts says further: "Besides the diseases mentioned, a very frequent cause of death in this period of life is an injury, especially among males. Of each 1,000 cases of death among males no less than 128 resulted from accidents and 67 from suicide, that is, almost 1 in 5 arose from some form of violence. Among females from 15 to 30 years

of age accidents which resulted fatally and suicide were much less frequent, only about 1 death in 22 or 23 being caused among females by such violence. In place of this, however, puerperal fever is frequently mentioned as the cause of death during the youthful age of 15 to 30 years, namely for 30 of each 1,000 females dying."

Tuberculosis of the lungs is also, according to these tables, the most fatal disease in the period of greatest vigor, the age from 30 to 60. Of each 1,000 males who died 222 succumbed to this malady, and 207 of each 1,000 females dying. The next most frequent causes of death in this period were diseases of the heart and of the blood vessels; 150 of each 1,000 females and 135 of each 1,000 males who died succumbed to such maladies. As in the previous period of life, heart troubles seemed to be more often fatal to women than men. In this age of 30 to 60 cerebral affections and spinal diseases become very noticeable as causes of death, for about one tenth of all the men died from cerebral apoplexy or of some diseases of the nervous system, the proportion of women dying from these diseases being not quite so large. In this period of life also cancer and other malignant tumors were a frequent cause of death. Such new growths are more frequent among women than men, being noted as the cause of death for about 3 of every 20 females dying and for about 3 of every 33 males. The large number of suicides and fatal accidents in the age from 30 to 60 is likewise very striking, for of all the causes of death among males about one twentieth, 4.9 per cent, resulted from suicide, and nearly one eighteenth, 5.8 per cent, from accidents. The percentage for such causes among women is somewhat smaller.

The official statistics show that after the close of the sixtieth year of life a frequent cause of death is old age. It is given for more than one third, 36.4 per cent of all women who died and for more than three tenths, 30.4 per cent of all men. There was apparently no disease or injury in these cases, but a wearing out of the organs of the body.

"If we leave aside," continues Dr. Rahts, "those who died apparently of old age, that is, take into consideration after the close of the sixtieth year only those who died from a more definitely designated disease or injury, we find that nearly one fourth of these died from some disease of the circulatory system, that is, from a disease of the arteries or heart, and probably the cause of death reported for the persons entered in this column of the tables has been largely a hardening of the arteries (arteriosclerosis). Further, fully the eighth of those not dying from old age succumbed to cancer or to the consequences of some other new growth, namely, 13.55 per cent of all such females and 12.12 per cent of all such males. Outside these diseases life at this advanced age is mainly threatened by cerebral apoplexy, pneumonia, or other disease of the respiratory system, as asthma or bronchial catarrh. In this period tuberculosis is apparently by far not so common a cause of death as pneumonia. Suicide, accident, or influenza are about equal as causes of death, namely for about 1 in every 60 males who died excluding those who died of old age. On the other hand, among elderly females suicide or fatal cases of accident causing death were noticeably less frequent than influenza."

There seems to be some danger for women in Germany of dying in childbed. During the decade 1892-1910 for every 10,000 living or stillborn children 36 women died in childbed, of whom about 16 died of puerperal fever, and about 20 of other results of confinement. Several diseases which are greatly dreaded elsewhere and which are easily conveyed, as small-pox, typhus, and leprosy caused but few deaths in the empire during the decade 1892-1902, as did also certain animal diseases to which human beings are susceptible, namely, hydrophobia, glanders, anthrax, and trichinosis. All these diseases just mentioned taken together caused the death in Germany annually of 2.3 persons in every million inhabitants, so that the danger from them in this country is very slight.

Artificial Production of Vigorous Trees*

Valuable Sports and Hybrids That Have An Interesting History

In an article on the artificial production of vigorous trees, contributed to the Journal of the Department of Agriculture and Technical Instruction in Ireland (No. 1, October, 1914) Prof. Augustine Henry discusses the nature of species, varieties, races, sports, and hybrids, as they appear to be from his researches. Natural species, in the case of trees, are readily recognized by the occurrence of each in a definite region or habitat. We have thus one species of silver fir in Central Europe, another in Algeria, a third in Southern Spain, etc. Of our common trees—oak, birch, and elm—there are pairs of species in the same region, each, however, occupying a different habitat, one species adapted to a dry situation, the other suited to a moister soil. The pedunculate oak is a native of valleys and alluvial flats. It is not protected against evaporation of water, the supply of which in the ground it prefers being always ample. The sessile oak is a native of hilly and rocky districts, where water is not abundant in the soil. Its leaves are covered beneath with hairs, which guard against excessive loss of water by transpiration in windy weather. Similarly two alders exist on the Continent, but only one species, *Alnus glutinosa*, reached our islands, after the retreat of the ice sheet, and before the land connection with France was severed by the formation of the Straits of Dover. The other species, *A. incana*, grey alder, is absent from our native flora, but when introduced is very hardy, and is useful for planting in low lying situations liable to spring frosts. The ash requires such special conditions of soil, that only one species exists in Northern and Central Europe, there being no suitable soil for a second species to inhabit.

A natural species is often a set of individuals uniform over a large area; but it may consist of two or more "geographical varieties," which correspond with distinct territories, each marked by slight differences of foliage, etc., that render the variety better fitted for its own habitat. Thus the Corsican and Austrian pines are closely related, but the latter keeps its leaves two years longer on the branches, so that the dense shade of its abundant foliage preserves moisture in the crevices of the hot limestone rocks, on which it grows in its Austrian and Servian home. The Corsican pine, with half the foliage of the other tree, thrives on granite soil in the moist insular climate of the mountains of Corsica. These two pines only notably distinct in one character, the amount of their foliage—are usually regarded as two geographical varieties of the same species, *Pinus Laricio*, but by some botanists are considered to be two distinct species.

In a species apparently uniform over a large area there may exist varieties, characterized by minute and scarcely describable differences. This is exemplified by the Scots pine. Plots of its seedlings, raised from seed of trees in the forests of Scotland, Russia, Switzerland, etc., differ in vigor and in other respects (immunity to certain fungi, etc.), when all are grown together under identical conditions. Such varieties, with slight differences of structure, may be called races, and are of great practical importance in forestry. Only seeds of the best race, that is, from vigorous trees of the most suitable locality, should be used.

A sport is usually a solitary phenomenon, arising either as a sporadic peculiar seedling from a seed, or developing out of a bud on a tree as a single branch with some peculiarity of twig or leaf. A sport may be looked upon as a freak, not forming the starting point of a new species, but speedily becoming extinct if left to nature. Sports, when of interest on account of the curiosity or the beauty of their appearance, are propagated usually by grafts, cuttings, or layers; being only in rare cases perpetuated by seed. Some sports are due to arrested development. The tree, in the course of its life, often passes through stages, like those of an insect. The seedling of many species differs from the adult tree as a larva from a butterfly. The infant ash has simple leaves. The sport known as the simple-leaf ash is simply a seedling ash, which has never progressed to maturity and may be called a persistent larval form.

Abnormal coloring of leaves, so-called variegation, is a sport, usually starting as a solitary branch on an otherwise normal tree, which, when noticed, is propagated by grafting. Deeply-lobed, crumpled, pitcher-like, and other abnormal leaves occur in many species, and are propagated as curiosities. In sports, reversion is often seen; thus on a fern-leaf beech one or two branches with normal leaves are not uncommon. This reversion may be due to the influence of the stock, as these sports are usually grafted: or it may be explained as the triumph locally of normal over abnormal factors. Such reversions are never seen in hybrid trees. The occurrence of a sport seems to predispose to further sporting; a tree with leaves abnormal in shape will sometimes take on, in one branch, abnormal color as well. These double sports are common in the holly.

Hybrids are combinations of two species or of two varieties, which arise either in the wild state or in cultivation. They are met with in nature as rare individuals on the boundary line between the area occupied by two species. This is well seen in Yorkshire, where a hybrid oak is found in the localities in which the sessile oak of the hills comes in contact with the pedunculate oak of the valleys. Hybrids arise frequently in nurseries, gardens, and parks, where several species are cultivated together.

Hybrid trees are more common than has been supposed. Many valuable trees, the real history of which has not been suspected by botanists, are of hybrid origin. As an example, may be mentioned the fine elm, which is universally planted in Holland and Belgium, where it is known as *orme gras* or *Ulmus latifolia*, Poederlé. This is not, as sometimes imagined, a natural species peculiar to those countries. It is unquestionably a hybrid, which is invariably propagated by layers, all the individual trees on this account being uniform in appearance. It seems to have originated three or four centuries ago, probably as a single seedling, which has given rise by vegetative reproduction since to millions of descendants.

The distinction between sports and hybrids is well known in the numerous so-called "varieties" of the holly. Some are sports of *Ilex Aquifolium*, our native holly; others are hybrids, one parent being the common holly, while the other is either *Ilex Perado*, which was introduced from Madeira in 1760, or *Ilex Balearica*, the holly of the Balearic Isles, which was cultivated at Versailles in 1789. Miller, in his account of the hollies in 1750, was acquainted only with the sports, which had arisen from the common holly, as the other species had not been introduced at that time and hybridization was impossible. The hybrids originated soon after 1800, the earliest apparently being *Ilex Hodginsi* and *Ilex Hendersoni*, which were found by Hodgins as seedlings in his nursery at Dunganstown, Wicklow. Here *Ilex Perado* was cultivated; and old specimens producing flowers and fruit freely are still common in Wicklow gardens. The holly hybrids are vigorous trees, bearing large leaves intermediate between the parent species. The sports of the common holly are always grafted, and are feeble in growth, with a tendency for single branches to revert occasionally to the normal form.

With regard to hybrids, Prof. Henry, by historical research and experiment, has established the fact that many fast-growing trees in cultivation as the Lucombe oak, common lime, cricket bat willow, black Italian poplar, etc., are hybrids. By artificial pollination he has succeeded in raising new hybrids, which display the extraordinary vigor characteristic of the first generation cross; and in his paper gives an account of these. The most notable so far are a hybrid poplar (*Populus generosa*) and crosses between the common ash and American species of Fraxinus.

* From Nature.

Advantages of Surface Combustion

An English firm introduced the Bowe system of surface combustion with liquid or solid fuels for which decided advantages are claimed. Among the special applications illustrated by the booklet are those to enameling, forging, annealing, bolt-making, glass-working, and metal-melting. It is stated that until recently it has been necessary in the enameling industries to employ muffle furnaces in the heating of the ware, for if the combustion gases gain access to it the lead oxide in the enamel is reduced and the work ruined. This effect is due to the incomplete combustion of the gases. As the result of a special test carried out by representatives of an important manufacturing firm, it appears that the combustion products of the new system do not impair the enameled surface, and, therefore, may be allowed to have free access to it, so dispensing with the necessity of muffles, and effecting a great saving in fuel. The advantages claimed for the system generally are: (1) The combustion is greatly accelerated by the incandescent surface, and, if so desired, may be concentrated just where the heat is required; (2) the combustion is perfect with a minimum excess of air; (3) the attainment of very high temperatures is possible without the aid of elaborate "regenerative" devices; (4) owing to the large amount of radiant heat developed, transmission of heat from the seat of combustion to the object to be heated is very rapid.

Electro-Culture of the Soil

A Discussion of the Part Taken by Electrical Processes in Biological Reaction

During the past few years there has been much speculation as to the effects of electricity upon the development of plants and various experiments have been made in the stimulation of germination or growth by electricity, either by the use of electric lights or by the transmission of currents of electricity to the plants or the earth. Results have varied, some investigators claiming great successes, while others express doubts as to the practical value of such methods, or even assert that crops of different kinds are injured by the use of electricity.

One of the advocates of the benefits of electricity for vegetation is Prof. Dr. W. Löb of Berlin, who read an interesting paper on the question at the session in Leipzig in May, 1914, of the German Bunsen Association for Applied Chemistry. Acknowledging that the problem was still unsolved, but claiming that the effort in any direction to settle it was of value, he reminded his hearers that under natural conditions vegetable life exists in the conductive surface of the earth and has above it the dielectric atmosphere. As electrical processes resulting from these conditions, there may be an electrolysis within the earth which produces a directed transmission of ions and a discharge of ions at the electrodes, or by cataphoresis the relations of the colloid substances of the earth or of the parts of the plants are shifted. There can, further, be a fall of potential in the layer of air surrounding the plants, followed by the seeking of equalization through the dielectric atmosphere with the ground or the surfaces of the plants. This latter form of influence is the one best suited for imitation in practical electro-culture, in which there is generally an insulated metal frame or an insulated metal lattice-work stretched parallel to the ground at a certain height above it and equipped with high voltage electricity, which is equalized with the ground by constant discharge.

The natural form of electrical energy to which this practical method bears the closest resemblance, that of silent discharge, opens up the question of the reactions attainable through the equalization of differences of potential by means of a dielectric, a question which extends far beyond the problem of electro-culture. For, as it is certain that the differences of potential necessary for the discharge exist in nature without the aid of artificial devices, they must co-operate in proportion to their chemical activity in the natural reactions. In regard to atmospheric electricity, Berthelot proved that differences of potential, which vary from 7 volts per meter in dry weather to 500 volts in damp weather, appear between layers of air, between air-surfaces and leaf-surfaces, or between the air and the ground. The equalization of these differences generally occurs in the form of dark discharges. Another form of continuous discharge at the earth's surface is the glow discharge. The part taken by sunbeams in generating the surfaces of potential-levels has been investigated of late years by Noden, and in the sunbeam, we should remember, besides the heat and light rays, ultra-violet rays are also active, the importance of which for ionizing in gases, or in the generation of electrons, is known.

All this led Dr. Löb, who had spent many years in investigating the chemical effects of the silent discharge to take up the problem of electro-culture in connection with the silent discharge and to make experiments to determine the part taken by the electrical processes in the chief biological reactions. In his address, which is given in the German journal *Zeitschrift für Elektrochemie*, he says:

"In order, first of all, to gain a general position to this problem, it is only necessary to recall that undoubtedly during the process of equalization of the differences of potential in the dielectric, if the dielectric is moist air, definite reactions are regularly caused, as, for instance, the formation of ozone, peroxide of hydrogen, and oxide of nitrogen. The further question naturally arises, whether these substances influence the vegetative processes, as the assimilation of carbonic acid and nitrogen, or processes of oxidation, whether they accelerate or retard the numerous enzyme reactions. It is also known that chemical reactions are not merely limited to the domain of gases, but that the interface between the ground and the air also causes reactions which directly affect the substances within the ground. Thus, Berthelot proved that a number of fixed bodies and fluid substances absorb nitrogen. If the ultra-violet rays are also taken into consideration, the number of possible reactions is much larger. Recently Neuberg, among others, showed how easily and completely many biologically important substances are changed by the ultra-violet ray."

These conditions and results lead to the deduction that electrical energy is of much importance in the reactions of life. The silent discharge seems to be especially suited for use in investigating such reactions because in it, under exclusion of higher temperatures, electrical energy appears united with the ultra-violet ray, as has been shown by Warburg, and because relatively strong chemical effects are produced.

Among the biologically important investigations undertaken by Dr. Löb are: "1. The assimilation of carbonic acid from moist carbonic acid over formaldehyde up to glycolaldehyde; 2, the synthesis of the fatty acids connected with the assimilation of carbonic acid; 3, the synthesis of glycocol from carbonic acid, water, and ammonia over the intermediate stage of the formamides, a reaction which may be regarded as the first phase of the assimilation of nitrogen in the process of the formation of albumen; 4, the hydrolysis of starch; 5, the removal of the amino group from glycocol."

When these results are compared with the reactions which can be produced in the atmosphere, as the formation of ozone, peroxide of hydrogen, and oxide of nitrogen, the reactions attainable by the action of the silent discharge may, according to Dr. Löb, be summed up as follows: "*a*, Direct syntheses or decompositions are produced from the substances of the atmosphere or of the conducting electrode (fluid or surface of the earth); *b*, substances are produced which either retard or accelerate other biological processes; *c*, reactions, the course of which only affect themselves, are accelerated or retarded directly by the influence of the electrical discharge, that is, without catalytic agents."

In company with Dr. A. Sato, Dr. Löb, about a year ago, took up the question whether the enzyme reactions, so important for the germinating plant, are modified in their course by the influence of the electrical discharge. To settle this point it was necessary to determine: the condition of the substrata under the influence of the discharge, whether the enzymes are affected by the discharge, and in what way the discharge acts upon the enzymatic modification of the substratum. The experiments had to be made both with atmospheric air, and under its exclusion in order to avoid the appearance of ozone, hydrogen peroxide and oxide of nitrogen, and involved tedious and delicate experiments.

As the experiments sought only to determine the main conditions, animal not vegetable enzymes were used, solutions of suitable dilution being made from the dried substance of the pancreas of hogs. The results showed that the enzymes and substrata used were matters of importance, so that there is a possibility that the action of the discharge upon the vegetable enzymes might be different from its action upon the animal enzymes. Among the most important enzymatic processes of the germinating plant are the diastatic, tryptic, and lipolytic reactions of the enzymes. In his summary of results Dr. Löb says:

"1. Watery solutions of starch are hydrolyzed under the influence of the silent discharge and the glow discharge in the presence of oxygen and under its exclusion. At the same time the part of the starch not hydrolyzed is altered in another way, perhaps in the direction of a *polymerization, so that* the part of the starch exposed to the discharge but not hydrolyzed has more power of resistance to diastase than starch not treated by electricity. 2. The diastatic properties of the pancreatic solutions are decidedly retarded by the electrical treatment. 3. The reaction between diastase and starch is retarded by the electrical treatment. 4. Peptonised silk (partially hydrolyzed silk) solutions are hydrolysed only slightly by the discharge, whereby a little free ammonia appears. The amount of the amino acids and of the non-colloidal nitrogenous substances are not demonstrably increased. 5. The tryptic properties are retarded by the discharge. 6. In the presence of peptonised silk the tryptic properties are not demonstrably injured through the peptone. 7. In the presence of fibrine the electrical treatment increases the tryptic properties which act upon this, the digestion of fibrine is accelerated."

It was, curiously, found that in some cases the discharge injured the enzyme when the latter was exposed to it without a substratum, while when the substratum was present the action of the enzyme was accelerated. The reason for this may be that the discharge changes the colloid condition of the enzyme and encourages flocculence. If this process begins without a substratum it is possible that the adhesion of the enzyme to the substratum is made more difficult should the latter be added later. *If the substratum is present during the development of flocculence*, the chemical affinities undoubtedly existent between it and its enzyme may influence the adsorption process between the two in the same direction, thus accelerating the enzyme reaction.

Another fact gained from the experiments is that the nature of the substratum is of importance for the effect of the discharge, which would imply that the sensitiveness of the specific character of the enzymes varies as regards electrical treatment. The reactions of vegetative life, assimilation of carbonic acid and nitrogen, process of oxidation and reduction, enzymatic decompositions of highly molecular substances, which frequently precede further transformations, as well as the numerous processes of polymerization and syntheses of other kinds, are all closely connected with the form of the supply of energy. Numerous questions arise as to the action of the sun's rays on the growth of plants and the connection of light and heat with electrical energy. These questions will have to be experimentally answered before the scientific basis of electro-culture can be laid.

In the discussion which followed the reading of the paper before the association at Leipzig some doubt was uttered as to the actual results of electro-culture, the opinion being expressed that the effects of electricity seem either negative or secondary. The necessity was also dwelt on for extreme caution in all such experiments, as ferment infections caused by ordinary micro-organisms could lead to mistaken deductions. F. Haber of the Kaiser Wilhelm Institute, at Berlin, gave the results of his investigation with others of the assimilation of a leaf of cherry laurel in air filled with carbonic acid. It was found that the electric field produced no change in the assimilation unless a glow discharge was obtained. Both continuous and alternating currents were used, also an alternating field was tried. The reaction produced by the glow discharge injured assimilation. The admixture of ozone or oxide of nitrogen with the air had the same effect as the glow discharge. The concentration was diluted until no injurious effects were perceptible, but no useful results were attained. In conjunction with these experiments, Messrs. Knight and Priestley of the Botanical Garden of the University of Leeds investigated the breathing of plants under the influence of electric fields and reached only negative results. These and the investigations of other scientists mentioned led him to the opinion that when success is obtained in electro-culture the question proves to be not that of electrical action upon one of the physiological functions of the plans, but merely that of an entirely secondary effect of electricity.

In reply to the inquiry how he supposed the glow discharge affected enzyme action, whether it was through the production of certain chemical substances which influenced this action, Dr. Löb said that any influence could only be on the surface, as the enzyme solution forms an electrode within which hardly any perceptible fall of potential could take place. The entire fall of potential occurs in the atmosphere; the reaction takes place on the surface of the fluid. Perhaps the best way to describe how the chemical action arises would be to compare the phenomena with the action of the ultra-violet ray. If ultra-violet rays are thrown on a sterilized solution of sugar the solution at once changes, it absorbs oxygen, oxidizing processes appear, etc. With the aid of the theory of electrons, various schemes could be advanced as to how this happens, but he did not wish to form a definite theory until more facts had been determined. C. Schall of Leipzig spoke of an experiment once made with an electrically charged metal in a solution with which it acted when not charged. It was claimed that the resulting yield was greater, so that perhaps the reaction was accelerated in some manner. It was also supposable that leaves charged at a fairly high potential, 100 volts, could, when the constituents there combined, act upon the speed with which a reaction takes place on the surface.

In reply to an inquiry as to how the experiments were made, Dr. Löb said the enzyme solutions were exposed to the discharge in suitable vessels, and simultaneously the same solution was set in a similar vessel without exposure to discharge. Then the enzyme strength of these enzyme solutions was determined, and it was settled whether the speed of the enzyme reaction had been increased or retarded in the hydrolysis of starch or in the digestion of peptone, casein, or fibrine. Next the behavior of the substratum without the enzyme under the influence of the discharge was investigated, and after all this the enzyme reaction on the substratum was allowed to go on to completion simultaneously under the effect of a discharge and without discharge. The result was quantitatively determined.

Fig. 3.—A physiological record of radio time signals. Irregularity in record is

Fig. 4.—A record showing extreme fatigue of the muscles.

Records of Radio Time Signals*

Made With a Physiological Recorder

By Prof. C. W. Waggoner, West Virginia University

From the date of Galvani's historic experiment with the frog muscle in 1786 to the present, physiologists have investigated the effect of electrical and mechanical stimulus upon this remarkably sensitive physiological mechanism. Helmholtz is credited with having made the first careful study of the muscle-nerve preparations in 1852 and the use of these preparations from the frog for the study of the characteristics of these tissues is common in all physiological laboratories.

This paper is a report on some records made with the muscle-nerve preparations of a frog of the radio time signals sent from the Government naval station at Arlington, Va., and received on a small aerial erected on the campus of the West Virginia University.

Dr. Lefeuvre[1] of the University of Rennes, France,

Fig. 1.—Receiving apparatus.

succeeded in obtaining some records of the wireless signals sent from the Eiffel Tower, Paris, by using the muscle-nerve preparation of a frog, transmission of such signals from Paris to Rennes being for the most part over very level land, and at a distance of approximately two hundred miles. He used a sensitive electrolytic receiver, shunting the recorder current around the high resistance telephones which were placed in series with the detector and potentiometer.

The distance from Morgantown to Arlington, Va., is approximately 182 miles and in between lie three big mountain ranges, one ridge of which rises 2,200 feet above the level of the campus. The aerial used in these experiments consisted of four cables of stranded copper wire, seven strands of No. 21 wire to each cable. The aerial is of the inverted L type, the highest point being 112 feet above the ground, and has sufficient length to give it a natural wave-length of 375 meters.

In Fig. 1, showing the receiving apparatus, *A* is an induction type receiving transformer which was constructed in our shop, and has a tuning range of 50 to 4,000 meters with a comparatively short aerial. *C* is a variable condenser of approximately 0.001 microfarad capacity. *W* is a buzzer-driven wave-meter, the inductance of which is loosely coupled with one turn of the aerial lead-in. The electrical connections are those commonly used for receiving long wave-lengths. The secondary of the receiving transformer is shunted by the variable condenser to insure ease in sharp tuning; around the secondary is also shunted a circuit containing the detector and a small fixed condenser in series. The terminals leading to the recorder are connected to a switch so that either the recorder leads or the telephones may be shunted across the small fixed condenser. The buzzer used to excite the wave-meter is of the type described by Austin.[2] The buzzer is very simple to construct and gives such a steady, high pitched note in the telephones that we have found it a very valuable addition to the general equipment of the laboratory. The buzzer shown in the figure will operate on two dry cells for six to eight hours at a time without requiring any adjustments or attention. Such a buzzer is essential to the most careful adjustments on the silicon detectors. The detectors are shown in the figure at *D* and are mounted upon a spring support. Simple silicon-steel detectors without batteries were used throughout these experiments, and it was found that they were amply sensitive for the recorder. The spring support for the detectors was found to be a great convenience. Those who have used this type of detector know how sensitive it is to a slight jar, and with this type of support there was no difficulty keeping several detectors in adjustment for weeks at a time without disturbing them in the least. The experiments were made during February and March of last year, and little trouble was experienced from static discharges in the atmosphere.

The mechanism for making the records is shown in Fig. 2. The frog is shown at *F* (the table upon which it was mounted was tilted to the vertical position for the photograph). The preparation was made by removing the frog's brain, destroying the spinal column and dissecting out the sciatic nerve which energizes the gastrocnemius muscle. The muscle was cut free at the lowest point and fastened by a cord to one end of the long lever shown at *L*. This lever, with a suitable sharp marker on its end, was arranged to move, at the contractions of the muscle, over a smoked paper kymograph *K* driven by a constant speed motor *M*. At *T* is shown a small Zimmermann time-marker which was adjusted to record seconds simultaneously with the record made by the muscle-nerve preparation. This time-marker has a fine Swiss watch movement, and a comparison of its record with the standard time record made by the muscle will show an error too small to be determined on the scale drawn on the record.

The method of making a record was to tune the receiving transformer with the aid of the wave-meter to 2,500 meters; then as soon as the signals began to arrive the telephone leads were replaced by the leads to the recorder, and the two platinum points or electrodes in contact with the nerve were moved along the nerve until a strong but regular response to the signals was obtained. The records were fixed by coating them with a thin solution of shellac in alcohol.

With a satisfactory preparation no difficulty was met with in getting full five-minute records of the time signals both at 12 noon and 10 P. M. (eastern time), often the same preparation serving to make records at both these hours. In a number of cases it was found that when a frog was prepared only a few minutes before making the record it was entirely too sensitive, and a complete tetanus would result from the stimulus of the first few signals, and no results could be obtained. After twelve or fourteen hours this same preparation would often give an excellent record. A few frogs were found whose muscle-nerve preparations failed to respond at all. This failure may be due to the fact that only winter frogs were to be had and at this time in their hibernation their vitality was probably very low.

Figs. 3 and 4 show some records made by this type of recorder. Fig. 3 shows a record made by a freshly prepared specimen. This record was taken at 10 P. M. and on record following the time dash at 10 will be found t weather signals. The muscle-nerve preparations will not respond to rapidly repeated stimuli, especially if the muscle is fatigued, as was the case in the record shown in Fig. 3, and it is of course impossible to interpret the weather signals from this record. It

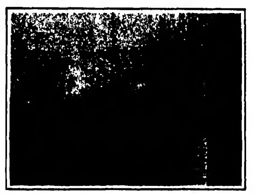


Fig. 2.—Recording apparatus.

was possible often to record the operator's signature at the close of the last time dash, but only when the frog was used in making signals for two or three minutes. Fig. 4 is a record showing extreme fatigue of the muscle. This record was made by a muscle-nerve preparation which had been prepared twenty-five hours before this record was made and the rapidly decreasing amplitude of the vibration indicates the fatigue.

From the experiments performed it seems that this type of recorder, while remarkably sensitive to small electrical impulses, is limited to slowly applied signals if the record is to be taken for any considerable length of time. A freshly prepared specimen will show complete tetanus if the impulses occur as rapid as twenty-five or thirty times a second. We were unable to get any very satisfactory records of the weather signals, except to record some of the numerals which consist of well spaced dots and long dashes, even with a freshly prepared specimen.

Like all recorders, this one responds to static discharges, and if the static current is very strong the high current tends to cause tetanus and ruin the record. It is possible that this type of recorder could be used by observatories in connection with the chronograph for finding the rate of clocks, making use of some sort of an amplifier, such as the Audion, in such stations so far distant from the sending station that the received current on the antenna would not be sufficient to operate the muscle-nerve preparation. The response to the signals is very rapid. Physiologists have found that this muscle-nerve preparation will respond to the stimulus in one-one hundredths of a second after the current has reached the nerve.

* A paper read before the American Physical Society, Washington, D. C.

[1] *Lond. El.*, vol. lxxi, 1913.

[2] Austin, *Bull. Bur. of Standards*, vol. vi, 1910.

in the speed of the kymograph. Decrease in amplitude shows muscular fatigue.

preparation had been made twenty-five hours before using.

Hydrogen, Its Technical Production and Uses*

By A. F. Seeker

In recent years the cheap production of hydrogen on a large scale for technical purposes has become a problem of some importance. Formerly it was used occasionally for filling balloons and in the oxy-hydrogen flames of the so-called "calcium light." Being the lightest of the common gases and of a correspondingly high sustaining power, it has become essential for the filling of dirigible balloons with their heavy burden of propelling machinery. Such uses, however, have become of rather secondary importance, and it will probably be only a short time before the dirigible balloon and the "calcium light" will have been permanently discarded in favor of heavier than air machines and varied forms of projected lights operated by electricity.

The oxy-hydrogen flame is now becoming a common tool in the hands of the artisan in working refractory metals; liquid oils and soft greases are now "hydrogenated" to produce acceptable lard and butter substitutes, and also solid fat suitable for the manufacture of hard soaps; and lastly, the use which promises to consume enormous quantities, ammonia is manufactured from hydrogen and atmospheric nitrogen. All these uses tend to make the problem of the production of cheap hydrogen one of considerable importance.

The employment of the oxy-hydrogen torch is too well known to require description here. The commercial "hydrogenation" of oils and fats is of recent introduction. The process consists in treating the oil or grease in a suitable vessel containing a catalyzing agent, generally nickel, with hydrogen under pressure. The oil is violently agitated in order to bring it into intimate contact with the hydrogen and catalyzer. The result is that the glycerol esters of the unsaturated fatty acids, which generally consist for the most part of oleic acid, become saturated, and the mono-, di-, or triolein, as the case may be, is converted into the corresponding stearin. The oleins are either liquid or semi-solid at ordinary temperature, and pr ce soft soap or soap that will not hold much water without becoming soft. The stearins are solid fats at ordinary temperatures and produce hard soaps. Thus by the process of hydrogenation, cotton seed and corn oils are to-day being converted into lard and butter substitutes, and the soft waste grease which formerly could only be used sparingly in soap on account of their softening effect can now be employed alone as soap stock. The importance of this is understood when the soaring prices of animal tallows are taken into consideration.

In view of the impending exhaustion of the Chile nitre beds, the problem of the fixation of atmospheric nitrogen for the manufacture of artificial fertilizers has received constantly increased attention. Electrical methods for the production of cyanamid from calcium carbide and nitrogen, and the flaming arc process for making nitric acid directly from the air have been established upon a successful commercial footing, but these require such an enormous expenditure of energy that they can only be operated profitably where there is an abundance of cheap water-power. If only these processes were available, countries lacking in water-power would be placed at a distinct disadvantage, and for this reason many chemists, particularly those of Germany, have labored to find a process better suited to the conditions surrounding them. The details of this search were described in a most interesting manner before the Eighth International Congress of Applied Chemistry, by Hofrat Dr. H. A. Bernthsen, who is the Chemical Director of the Badische Anilin und Soda Fabrik, the owners of a synthetic ammonia factory now in successful operation at Oppau.

* The Chemical Engineer.

The process, which has been named after Haber, its inventor, consists in passing a mixture of pure nitrogen and hydrogen under a pressure of 150 to 250 atmospheres through a tube filled with a catalyzer and heated to 650 deg. to 700 deg. Cent. The hot gases then pass through a heat regenerator and thence through an ammonia absorber, after which they are replenished with fresh gas mixture and forced by a pump back over the outer walls of the contact tube and then through the contact mass to repeat the circulatory course already described. Only a part of the gas mixture is converted into ammonia by a single passage through the converter, but the gases are made to circulate continuously through the apparatus, the ammonia being absorbed each time as the mixture issues from the heat regenerator at the end of the contact tube. The gases are replenished with fresh hydrogen-nitrogen mixture as required. The contact mass consists of pure iron containing small amounts of certain so-called promoters which may consist of oxides, hydroxides, or salts of the alkalies or of the alkaline earths, and also many other substances of the most varied nature, especially metallic compounds or the metals themselves.

There have been many ways proposed for the producing of hydrogen on a large scale, the most important of which are the electrolytic and the water gas process. The studies of A. Wegener and others lead to the belief that at an altitude of about 75 miles the atmosphere consists of pure hydrogen and nitrogen that would be ideal for the Haber process. Unfortunately no means of piping these gases down to our sphere of action are known and we must content ourselves with more laborious methods of production.

At European army posts, hydrogen for military balloons is commonly generated from scrap iron and sulphuric acid, the reaction being accelerated by heating the mixture to about 55 deg. Cent. For field operations zinc is used in place of iron and the generators are mounted on wheels to facilitate transportation. Three other, and more modern means, of generating hydrogen are used for field purposes and will no doubt be adapted for other than military uses in places difficult of access where the gas is needed. These processes were invented by G. F. Jaubert, a Frenchman, and were named by him respectively, the "Hydrolith," "Silicol" and "Hydrogenite" processes.

Hydrolith is formed by heating metallic calcium in an atmosphere of hydrogen, producing a hydride, CaH_2, which when treated with water reacts as follows:

$$CaH_2+H_2O=Ca(OH)_2+2H_2$$

just as calcium carbide generates acetylene. Hydrolith is a white crystalline powder, decomposing at 600 degrees in a vacuum, and usually contains about 90 per cent of CaH_2, the rest being nitride and oxide. One kilogram yields about one cubic meter of hydrogen. The apparatus designed for using hydrolith in the French army is very ingenious, can readily be transported and has a capacity of 1,200 cubic meters per hour. An army dirigible can be filled in four hours. The high cost of hydrolith, \$1.33 per kilogramme, will at present seriously restrict its use outside of military operations.

The Silicol process consists in treating powdered ferrosilicon, or mangano-silicon with water and caustic soda. It does not appear to have gained extended use because of the more troublesome manipulations and the greater difficulty of controlling the evolution of gas as compared with the other methods.

Hydrogenite is composed of ferrosilicon (containing 90 to 95 per cent of metallic silicon) 25 parts, caustic soda 60 parts and dry slaked lime 20 parts. The ingredients are reduced to a very fine powder, intimately mixed, and pressed into brick weighing 25 to 50 kilogrammes. Being very hygroscopic, each brick must be sealed in a tin box to prevent decomposition. In generating hydrogen the brick is placed in a metal chamber having double walls, the space between the two walls being filled with water. Vents are placed in the upper part of the inner wall leading to the central chamber containing the hydrogenite so that the steam formed during the combustion may gain access to the charge and increase the yield. The cover of the tin containing the hydrogenite is opened, the tightly fitting lid of the generator fastened in place and through a small hole in the latter a red hot wire is thrust into the charge. The mass burns quickly, without flame, generating heat and evolving hydrogen according to the equation:

$$Si+Ca(OH)_2+2NaOH=Na_2SiO_3+CaO+2H_2$$

One volume of the compressed hydrogenite yields 800 volumes, or 270 to 370 liters per kilogramme, of pure hydrogen, at a cost of about 32 cents per cubic meter. The requisite apparatus for field purposes weighs about 900 kilogrammes.

The methods employed upon a large scale are, of course, capable of producing the gas much more cheaply. In one of these an iron, clay lined retort is filled seven-eighths full of coke, ignited and raised to a white heat by an air-blast. The retort is then closed and a cheap hydrocarbon like crude petroleum or coal tar is injected into it from the top for about 20 minutes or until the temperature has fallen below the proper cracking point, the gas thus generated passing through a sprinkling tower and filtered into the gasometer. The oil injector is then shut off, the retort opened, the air blast again turned on, and the process repeated indefinitely with periodical renewal of the coke and removal of the ashes. The product contains about 2.7 per cent CO, 96.0 per cent H, and 1.3 per cent N, and has a specific gravity of 0.1. The gas can be still further purified to a content of 98.4 per cent H, by passing it through suitable absorbents, and is produced at a total cost of 3 to 4 cents per cubic meter, according to the size of the plant and the materials used.

Large amounts of hydrogen are obtained as a by-product in the electrolysis of salt solutions in the manufacture of chlorine and of caustic soda. The electrolysis is effected in a cell having a cement diaphragm which is not attacked by chlorine or caustic soda. The electrodes are iron and carbon, the latter being used as an anode. The reaction which is as follows:

$$2NaCl+2H_2=2NaOH+Cl_2+H_2$$

yields 7,000 cubic feet of hydrogen for every ton of salt. A cell operates on 15,000 horse-power at Griesheim, Germany, producing 215 million cubic feet of hydrogen per annum.

Two other methods, now little used, consist, (1) in passing superheated steam over red hot iron, and (2) in conducting water gas through suitable absorbents so that the carbon-monoxide and hydro-carbons are removed, leaving behind the hydrogen and nitrogen. A third process which is increasing in application was devised by Linde, Frank and Caro. In this, water gas which consists mainly of carbon monoxide and hydrogen is compressed and cooled to the liquefying point of the carbon monoxide. Upon relieving the pressure the mixture expands and in so doing is cooled still further so that the carbon monoxide and most of the impurities separate out in liquid form, allowing the hydrogen to pass off in a fairly clean (97 to 98 per cent H) condition. The mixture containing the liquid carbon monoxide is later vaporized and used in combustion motors for power.

The growing demand for cheap hydrogen for industrial uses will act to promote improvements in both the electrolytic and the water gas processes because both require comparatively cheap raw material.

Electric Waves and Oscillations

A Means of Investigating the Interior of the Earth

By Dr. Gotthelf Leimbach

The attempts which have, until very recently, been unsuccessful to utilize electric currents and waves in the investigation of the interior of the earth extend back, respectively, to the years 1830 and 1901. The first practical results in this field, attained by Heinrich Löwy and myself in 1910 and 1911, attracted by no means the attention in mining circles that we had anticipated. Even at the present day, in the face of a great number of successful achievements, many persons are still skeptical about the development of electro-dynamic methods of exploring the earth. Judging from my experience, this is due especially to the fact that neither the physical basis nor the scope of the various processes in question are correctly understood. Wireless telegraphy, the most familiar application of electric waves and oscillations, is commonly accounted one of the marvels of modern times; while the application of the same phenomenon to subterranean exploration is consigned to the realm of fable. In the following remarks I hope I may be able to convince the reader that the latter application is neither impossible nor incomprehensible.

The physical principles involved in this subject were discussed in detail in the journal *Kali*, volume 7, 1913, No. 17. I there explained the principles of the wireless transmission of electrical energy through space, in order to save practical mining men the necessity of consulting a work on wireless telegraphy. Hence, I shall in the present article limit myself to a short sketch of the various processes.

The possibility of applying electrical waves and oscillations in the investigation of the earth's interior depends upon certain physical differences in the materials constituting the earth's crust. The latter fall into two classes, according as they conduct electrical currents, or, on account of their slight conductivity, are classed as insulators. Good conductors of an electrical current are impervious to electrical waves, whereas the latter pass almost unaffected through insulators.

As electrical waves differ from light waves only in wave-length, optical phenomena may be directly reproduced by the former. With an apparatus for emitting waves (a sender) and one for recording them (a receiver), we may make qualitative observations on the material lying between the two instruments. As stated above, materials that are conductive to an electrical current will not permit the passage of the waves. Among the conductors are water,[1] salt solutions, and strata saturated with these; also a large number of ores.

I. INVESTIGATION BY MEANS OF ELECTRICAL WAVES

a. Absorption Method.

A first practical method of investigation, the absorption process, takes the form of testing rocks for the presence of various substances by examining their capacity for admitting the passage of electrical waves. Practical investigations of substances which are opaque to such waves (ore and salt solutions) were made by Dr. Löwy and myself in the slate mine of Rommelsberg, near Goslar, and also by Dr. Löwy at Scharley. These confirmed the fact that good conductors of an electrical current are opaque to electrical waves. A fair agreement with the theory, i. e., absence of marked absorption, was yielded by the rocks occurring in potash mines; viz., various salts, anhydrite, clay, etc. Numerous investigations in a large number of mines proved that there could be no doubt about the transparency to electric waves of the rock-forming minerals constituting the earth's crust—the ores excepted—when these substances are *dry*.

b. Reflection Method.

The reflecting power for light-waves of a great number of substances is as accurately known as their various degrees of transparency. Among the excellent reflectors of electrical waves we find, again, the substances that are conductive to an electrical current, viz., metals, ores, salt solutions, and water. With senders and receivers of electrical waves which have their antennæ so arranged as to send or receive only in a selected direction it is possible, therefore, to locate these conducting substances through intervening material that is transparent to waves, merely by changing the direction of the antennæ. From the angles between the antennæ of the sending and receiving instruments, respectively, and the ground when the intensity of the signals received is greatest, the depth of the reflecting layer (ore or water) can be computed. Practical investigations at the swimming hall in Göttingen, and also at Barsinghausen and Scharley, have proved the strong reflecting power of water and ore.

c. Interference Method.

In many cases, e. g., in determining the location of a water-bearing seam in the interior of a mine, it is impossible to use long antennæ, movable at will. Such a seam may, however, be located with stationary sender and receiver if the wave-length of the system is so chosen that the waves running directly from the sender to the receiver are neutralized by those reflected from the conductive substance. This will happen when the path of the reflected waves is longer by ½, 1½, 2½, etc., wave-lengths than that of the direct waves. The two trains of waves have a different direction of oscillation, and opposite phase; their effect upon the receiver will be *nil* in case they have equal energy. On the other hand, if the difference between the length of path amounts to one or a number of whole wave-lengths, the waves will then be of the same phase and their effect upon the receiver will be reinforced. As we are able to vary at will the wave-length of a sender and a receiver, we can ascertain by this method, as by the others, the presence and the depth or distance of a conductive reflecting seam. Experiments of this sort on a small scale were made by the writer many years ago in connection with investigations of quite a different character, viz., the study of moist soils, at the geophysical Institute of Göttingen University.

d. "Quarter-wave-length" process.

In the method above outlined both a sending and a receiving system are used. About a year ago it occurred to me to ascertain whether the wave emitted by the sender and returning thereto after falling vertically upon a reflecting surface would not affect the oscillations of the sender in a manner analogous to what occurs in the interference method. A method depending upon this principle would have the advantage of great simplicity, as compared with the interference method, because it would eliminate the second receiving system. In the laboratory of the "Erforschung des Erdinnern G. m. b. H." ("Subterranean Investigation Company, Ltd.") at Göttingen, experiments on a small scale gave the surprising result that reflecting surfaces could be located the length of which was less than that of the antenna and the breadth only one hundredth the length of the antenna, or less. This method is, therefore, extremely sensitive. As the sender shows particularly characteristic effects for differences of a quarter of a wave-length or multiples thereof, this process has been called the "quarter-wave-length" method. From the position of the characteristic maxima and minima of the effect of the reflected waves in relation to the wave-length the depth of the reflecting layer may be very accurately determined. This method is appropriate for seeking ore or water from the earth's surface in all cases where the intervening strata do not wholly absorb the waves. An expedition sent out by the company above mentioned, under the auspices of the Imperial Colonial Office and other interested parties, is now engaged in prospecting by this method in Southwest Africa.

II. INVESTIGATION BY MEANS OF ELECTRICAL OSCILLATIONS.

The following methods work with a single system of apparatus and depend upon the influence exerted on the apparatus by its immediate environment. The quarter-wave-length method therefore forms a connecting link between the methods in which the course of electrical waves is followed between two stations and those which involve observations of the influence exerted by the environment upon the oscillations of a single system.

a. Capacity and Damping Method.

The wave-length, λ, of an oscillating system, e. g., of an antenna, is determined by the latter's self-induction, L, and capacity, C, according to the relation $\lambda = 2\pi\sqrt{LC}$. The surroundings of the antenna have no influence on the self-induction, which therefore need not be considered further. On the other hand, the capacity of an antenna is strongly affected when the lines of force running from the positive to the negative end of the antenna pass through some medium other than air. Each substance possesses its own dielectric constant—a number analogous to specific gravity—which shows how many times the capacity of an electrical system is increased when operating in the substance in question instead of in air, the dielectric constant of which is unity.

The use of this principle of various dielectric constants in different substances seems quite pertinent when we learn that water has a constant of 81, while most rocks have constants varying between 4 and 12. We may therefore assume that the presence of a water-bearing seam will make itself felt through an increase in the capacity of the antenna, even at considerable distances. That even the slightest differences in the dielectric constants of various rocks occurring in potash mines cause differences in the capacity of oscillating systems has been determined through the detailed investigations of Dr. Erich Mayer and myself.

A great advantage of this method consists in the fact that substances having different dielectric constants affect not only the wave-length but also the damping of the oscillations in different degrees. In conductive substances energy is used up in the production of vortical currents, and to these substances belong, as we have said, water and salt solutions. Non-conductive substances of high dielectric constant virtually affect only the capacity of the system. Hence, this method should permit not only the discovery of the presence of substances of different dielectric constant, but also at least a qualitative identification. Thus we have the basis of a method which can be applied, first of all, in mining and shaft-sinking, to the task of determining whether there is danger of an irruption of water or salt solutions.

b. Examination of Frozen Shafts.

Water-bearing and unstable soils are now, with increasing success, frozen in connection with shaft-sinking, in order to produce a cylinder of resistant material within which the sinking of the shaft can proceed without danger. That this operation has not always been successful is due to the fact that it has hitherto been difficult to determine whether the frozen layer was sufficiently solid at all points. The efforts to remedy this difficulty have been limited practically to the construction of more or less trustworthy sounding-devices for testing the behavior of the various freezing-pipes. From the behavior of any two successive pipes, and with the aid of the data deduced from past experience, it is decided whether the amount of cold applied is sufficient to freeze the section of ground between the pipes, or whether a supplementary freezing-pipe ought to be installed between them. Moreover, in order to freeze with tolerable certainty any strata containing salt solutions, which have led to many breaks and accidents, very low temperatures are used. In spite of all improvements, the fact remains that there has heretofore been no means of promptly detecting the presence of disturbing factors within the earth. Here again the aid of electrical oscillations may be invoked. Unfrozen water-bearing or solution-bearing seams lose their electrical conductivity in proportion as the water they contain is changed to ice. Hence, the iron freezing-tubes must be used as antennæ and made to give rise to electrical oscillations, which will be effected by the immediate environment in the same manner as in the capacity method. Experiments on a small scale confirmed the utility of this process; ice was found to be transparent to electrical waves. The conductivity of water containing a small admixture of salts was reduced to about $\frac{1}{100{,}000}$ of its original value by cooling from room temperature to 10 degrees below zero Centigrade.

Meanwhile it remained to be determined whether these assumptions would be as perfectly realised in an actual shaft-freezing operation, with its envelope of frozen soil, as in experiments on a small scale. We had no difficulty in transferring our laboratory experiments to the practical conditions of such an undertaking. My collaborator, Dr. Mayer, and myself were able within a few minutes to excite oscillations of a previously determined wave-length in any freezing-tube we happened to select, at an installation between Rössing and Barnten where the necessary facilities were kindly placed at our disposal by the "Tiefbau- und Kälteindustrie A.-G." of Nordhausen (formerly Gebhardt & Koenig). The last preliminary condition of the proposed method was thus fulfilled; the frozen envelope of the shaft gave an effect exactly analogous to that produced under artificial conditions in the laboratory.

Our request for permission to continue our experiments at the Glitten shaft was cheerfully complied with by the "Deutsche Schachtbau-Aktiengesellschaft" of Nordhausen. With funds raised on the strength of our success at Rössing-Barnten, we only succeeded in test-

* Translated from *Zeitschrift des Vereines deutscher Ingenieure.*

[1] Pure water is a non-conductor. The author's statement is, however, true of all water found in nature, this being conductive in virtue of the substances it holds in solution.—Translator's note.

ing the frozen wall of the shaft so far as to discover, at the outset, the presence of an unbroken layer near the surface, which hindered the penetration of the electrical waves to the lower end of the freezing-tubes. This layer, according to our measurements, lay at a depth of barely 2 meters. Subsequent investigation showed that a thin layer of the freezing-mixture lay upon the cement block in which the drive-pipes were installed, and this had not frozen.

Had not the shaft been, for the most part, already lined with iron, we should have been able to apply successfully here a method which we have applied, with good results, in a Hanoverian potash mine, where we had to work through a much more strongly conductive layer than the one above mentioned. However, both here and also a few weeks later in a shaft-freezing installation kindly placed at our disposal at Heerlen, Holland, by the "Deutscher Kaiser" Mining Company, we had to content ourselves with the positive result of having been able to detect not only the presence but also the depth of an unfrozen seam, which lay even deeper at Heerlen than in the case just referred to.

Recognizing the fact that we must, for the future, generally expect such layers of disturbance near the earth's surface, and a more or less extensive iron lining in the shaft, I endeavored to devise another method in which the investigation of the freezing wall of the shaft would be entirely unaffected by such obstacles. The ample equipment of our physical laboratory greatly facilitated this undertaking. Setting out from certain very definite experimental conditions, my colleagues, Drs. Mayer and Kröncke, and myself succeeded in exciting electrical oscillations in two bare wires buried in wet earth—representing a freezing-tube system on a small scale—and in determining the constants which furnish information as to the separation of the tubes and the location of unfrozen places in the frozen wall. After experimenting under a variety of conditions we came to the conclusion that the presence of a conductive layer under the sill of the superstructure, due to the often practically unavoidable spilling of the freezing solution in filling the tubes, and also the existence of an iron lining ("tubbing") in however advanced a stage of construction, need not interfere with the examination of the frozen earth; indeed, the iron lining can be turned to good advantage in connection with this process.

c. Investigations in Connection with the Cementation Process.

The use in shaft-sinking of the cementation process, in which crevasses in the wall of the shaft are closed by forcing cement into them, has steadily gained adherents notwithstanding numerous failures. Unquestionably this process has its advantages in many cases, especially when water needs to be kept out in comparatively small areas at great depths. While in the freezing process it is possible to form a tolerable idea, through various modes of observation, of the successful progress of the work, in the cementation process the measurement of the water flowing into the drill-holes, or of the amount of cement forced out by the water, furnishes the only method of testing the solidification of the dangerous crevassed strata. The strong outward resemblance of the cementation to the freezing process led me to consider the applicability to the former of the electrical method of testing for water. The method used in the freezing process could not be applied without modification, since in this case it was not a question of insulating the drill-holes from water-bearing seams. However, preliminary experiments at Göttingen and also in an actual shaft where cementation was in progress showed that the waves from a highly isolated antenna can penetrate so deep in the earth that from the reaction of the earth upon the antenna it is possible to gain a knowledge of the presence of water in crevassed strata. An advantage offered by the electrical test consists in the fact that the antenna is not essentially affected by thin newly-formed layers which diminish the flow of water, take up little cement, and thus give a deceitful effect of solidity, but which, with further sinking of the shaft, do not offer sufficient resistance to the pressure, and thus may ruin the shaft. So long as the water is not effectually held back by the cement, so as to furnish the conditions necessary for forming a cement wall strong enough to withstand the very heavy pressures to which it may, under some circumstances, be subjected, the danger of a break may still be detected by our instruments, even in cases where the almost complete cessation of flow would, according to previous experience, apparently justify the further sinking of the shaft.

CONCLUSION.

The foregoing remarks will, it is hoped, help to give the reader some idea of the principles underlying the various methods of investigating the interior of the earth by means of electrical waves and oscillations, and to stimulate his interest in the practical results thus far attained. These results will be discussed in another article.

[In addition to the article in *Kali* mentioned above, several accounts of the methods of investigation described in the foregoing memoir have been published by Dr. Leimbach and his collaborators in German and Austrian scientific journals, the more important being:

H. Löwy and G. Leimbach, "Eine Elektrodynamische Methode zur Erforschung des Erdinnern (Erste Mitteilung)," *Physikalische Zeitschrift*, 11, 1910, p. 697 *ffg.* *Ibid.* (Zweite Mitteilung), *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, 60, 1912, p. 627 *ffg.* and p. 640 *ffg.*

H. Löwy, "Systematische Erforschung des Erdinnern mittels elektrischer Wellen," *Zeitschrift fur praktische Geologie*, 19, 1911, p. 207 *ffg.*—Editor of SCIENTIFIC AMERICAN SUPPLEMENT.]

German System and Method*

The Effect of the War on Her Industries

THE significance of the two words "system" and "method," and of all that these words connote, has been demonstrated to the full in the present war by the Germans, who, with much pride and satisfaction, make innumerable references to them in the press, in public meetings, and in private conversation. We all know that Germany, in every conceivable field, has carried her principle of systematizing to a length and degree of perfection unapproached and, perhaps, even hardly attempted in other countries, and however difficult her position may be at the present day and in the future, it would have been infinitely worse had she not had her system of systems to fall back upon. Its immense machinery was at once put in action, and the Germans claim for it that, when put to the tremendous test set it by the war, it has done all that could possibly have been expected from it.

At the recent general meeting of the Allgemeine Elektricitats Gesellschaft a statement was made that "the first task for the German industry, which through the war had experienced an unprecedented 'narrowing in,' was that of standing on its legs. To do this, a transformation of the entire industry was to some extent necessary. Although it certainly was by no means a simple matter for a country with many imports suddenly to get substitutes, the necessary transformation or alteration within the whole industry has been completed with admirable ease." Commenting upon these remarks, a writer in a Berlin journal says this only confirms what every day and every hour they see and hear and read. There is hardly an industrial report which does not bear out that, after the shock, work has been resumed with 40, 50, or 70 per cent of the usual staff, and that part of the work, directly or indirectly, has been devoted to war purposes. A factory for incandescent lamps all at once took up the manufacture of cartridges; machine works made "Gullasch-cannons"; a maker of artificial flowers went in for bread-bags, a bijouterie concern for knapsacks; a hotel kitchen was turned into a jam factory. It only took a couple of weeks, and the necessary plant was available. Hands were trained, and energetic merchants looked to the supply of raw materials, or where the usual ones were unobtainable, of substitutes, and to means to bring producer and buyer in contact, though often by a roundabout way. The system has worked admirably, and at a time when people were compelled to work with the utmost economy it has managed to call forth from the darkest and narrowest corners raw materials, to secure that nothing was wasted, and that no possibly accessible foreign source of supply was neglected. The fact that a number of earnest and financially strong business men were compelled to apply themselves to opportunistic dealings has also helped to augment the exceptional work done in this connection.

In examining into the reasons why German industry has escaped being brought to a standstill by the war in nearly every one of its more important sections and, after a short reorganization and with partly altered objects in view, has worked on with an imposing certainty and without any suspicion of nervousness, it becomes clear that the most potent factor is that the German army quickly succeeded in carrying the war into foreign countries. In addition to this, the industrial and financial authorities succeeded, by wise measures, in establishing confidence in the power of resistance of the German industrial organization, which, in its turn, rested upon the German military successes. The causes of the uniform continuity in German industrial growth, however, in the last instance are to be found in the fact that German development, more than that of any other country, has grown systematically, and shows no gaps of any moment in the manufacturing processes. With regard to certain raw materials which the German soil does not produce, or, in any case, not in sufficient quantities, Germany will also in the future have to depend upon foreign countries, even if the efforts of its scientifically working industry are systematically centered upon replacing artificially the natural raw materials which Germany lacks. In this connection mention is made of the successful attempts at producing artificial nitrogenous manure instead of Chile nitrates, at producing home-manufactured benzol in place of foreign benzine, and of the not yet quite successful attempts at producing artificial leather and rubber.

Still more important than the raw-material question for the maintenance of the collective German industry under the present conditions is the fact that no indispensable intermediate link is missing in the large processes of production. Germany produces herself all her half-finished goods, and she utilizes the residuary products of her industrial processes for the manufacture of valuable auxiliary commodities with such financial results that no other industrial nation in the world even approaches her in this respect. What these auxiliary products mean to Germany at present is more especially demonstrated by sulphate of ammonia and benzol. How much the want of important links in production can harm a country in her industrial processes is demonstrated in England, where the inadequate development of many auxiliary and vital industries has almost crippled some of the country's chief lines of manufacture. Thus, the stoppage of the German dyestuff import, which, in money, only represents about a million sterling, threatens the English textile industry, the English wall-paper industry, and many other branches, with a turn-over of many millions. In the same way the absence of cheap German half-finished goods has deprived the English iron industry of an important intermediate link. Further, the stoppage of mining timber has gravely inconvenienced the collieries.

Industrially, the long established and growing British principle of producing entirely finished goods, and importing the raw and intermediate products of great industries, has proved inferior to the German method in time of war. This latter aims at a complete organization of an entire manufacturing process in comprehensive works, which, separately or together, cover the entire series of operations needed. The industrial expansion of Germany, although it is much younger than that of England, has been laid out on more systematic lines, and in such a way as to render the country more independent of foreign aid. Under the difficult and strenuous conditions of war it has demonstrated the extreme value of system and method, and the advantages which they confer on a nation when it is cut off from the lands from which it draws its raw materials.

* From *Engineering*.

The Government to Certify Timepieces

THE test and certification of watches, chronometers, and other timepieces has been carried on for many years at the Kew Observatory in England, at the Besançon Observatory in France, and at the observatories of Geneva and Neuchatel in Switzerland, but no such tests have been made for the public in this country, except for a few years at Yale University many years ago. This line of work is now started at the Bureau of Standards, and Circular No. 51, entitled "Measurement of Time and Tests of Timepieces," has just been issued giving the regulations under which the tests will be made, the methods employed, together with sections on the use and care of watches, and on standard time and the sources of reliable time standards with which one may make frequent comparisons of his watch. This first edition of the circular announces the regulations for the test and certification of watches only; the test of other timepieces will be taken up later. It is expected that the tests will be especially valuable in cases where watches are to be used for scientific purposes or exploration, and also to purchasers of high grade watches in giving them assurance that the watch is reasonably adjusted and in good condition at the time of the test. Copies of the circular and also of the application blank may be obtained upon request from the Bureau of Standards, Washington, D. C.

The Hydraulic Mining Cartridge*

A Mechanical Device for Use Where Explosives Are Impossible

By James Tonge, M.I.M.E., F.G.S.

THE difficulty of removing rock and other material, in places where the shock attendant upon blasting operations would be damaging and dangerous to surrounding strata or foundations, is one which has not hitherto been thoroughly overcome.

The enormous initial power generated by the sudden decomposition of explosive substances has enabled great quantities of natural or artificial beds to be displaced, and a great portion of the work of the civil and mechanical engineer is involved either directly or indirectly in operations of this kind. The objection to the use of explosives, however, in many circumstances, is that the effect of blasting can seldom be harnessed or controlled so as to prevent the disintegration of the material beyond the area which it is desired to dislodge. In the case of many metalliferous mines, and sometimes of quarries, this is not a great drawback as it may not only be unnecessary to limit the operation of the "shot," but it may be actually desired to have the material in a pulverized condition. Even in this case, however, it should be remembered that this is not an economical means of

Fig. 3.—Operating the hydraulic cartridge in a coal mine.

obtaining such a result, for pulverization by explosives involves enormous waste of power as it usually represents great excess of explosive charge; in other words, the use of explosives must involve either the risk of accident through an insufficient charge or the production of misapplied energy.

It is for the purpose of avoiding these drawbacks and in order especially to take greater advantage of natural lines of cleavage or of bedding in the material to be dislodged that efforts have from time to time been made to provide what may be termed more rational or scientific means in the shape of mechanical substitutes for blasting.

The simplest form of mechanical means for breaking ground is, of course, the wedge, and this is used in varying lengths and shapes, in metalliferous and in coal mining, in all parts of the world. Various improvements on the simple wedge have been used at various times, viz., the stub and feather and the multiple wedge. The former consists of a steel "stub" or wedge driven in between two tapered liners of steel called "feathers" which have their thin end near the front of the hole. The multiple wedge is placed in a hole previously drilled and has liners also, but a pair of "feathers" may be inserted between them, driven up as far as possible, and then a second or a third "feather" may be used until the rock or coal is broken down. In coal mines, special efforts have been made to devise mechanical wedges capable of breaking down coal, notably those invented by Bidder, Burnett, Shreeve and Hall, and these have been used to a greater or less extent in a few mines. In some of these the wedge was driven in by means of a screw and handle, like a hand drilling machine, and in one case by hydraulic power.

These machines are not now in use and it may be taken that they have proved to be impracticable. This is no doubt due to the great pressure put upon them, even under favorable conditions, and the difficulty of devising and supplying a hydraulic pump capable of working at high pressure for a considerable time. It must also be remembered that a mechanical wedge must perform more work than that required to wrest the rock or coal from its position, as a certain amount of power is consumed in overcoming the friction of the sides of the wedge as it is driven up. Again, it is a disadvantage to have the material at the front of the hole breaking away as the wedge enters—the full weight of the falling material should, if possible, be utilized to assist the operation. With this object in view, machines have been designed to operate at the back of the hole first, the wedge being drawn towards and not driven from the front. Except in the case of the simpler forms it may be said that no mechanical wedges are now being used with success for excavating purposes of any kind.

The Hydraulic Mining Cartridge.—The hydraulic mining cartridge differs from all other mechanical substitutes for blasting. It is not worked on the principle of the wedge, and consequently the power expended in forcing a wedge into the hole is saved. Instead of employing

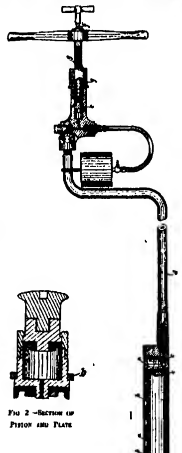


FIG. 2.—SECTION OF PISTON AND PLATE

Fig. 1.—Sectional elevation of the hydraulic mining cartridge.

a wedge, the disrupting effect is obtained by means of a number of small rams or presses working at right angles from a strong cylinder of steel. (Fig. 1.) In order to make these rams more effective in their operation, by obtaining a greater travel from their original position, they are made of a duplex or telescopic form, one part sliding and fitting upon the other (Fig. 2). In some cartridges these pistons operate from each side of the cylinder alternately, thus greatly increasing the travel. To retain the rams in position, a sliding plate is used fitting in grooves in the barrel (*b* Fig. 1); this is so formed and secured that it is perfectly rigid and firm when the machine is in operation, but is readily removable if it is desired to detach or replace any of the rams. By a suitable arrangement of passages (*c* Fig. 1) a communication is made between each of the rams, whereby simultaneous action is obtained. Machines are made of various diameters, viz., 2½ inches, 3¼ inches, and 4 inches, and of various lengths, say with 3, 6 or 5 rams, the smaller diameters having the larger number of rams. Pressures of 3, 4, or 5 tons per square inch are usual, so that machines are made to withstand great stresses.

The Pump.—The cartridge is operated by means of a pump (Fig. 1) to which it is directly connected by a pipe (*d*). The pump is of special design. At the commencement of the supply of water it is desirable that the latter should be supplied in such quantities as to fill up quickly all the spaces within the rams and passages, while at the same time allowing the operator, when the rams begin to move and the pressure to increase, to supply a less quantity of water, but at a greater pressure, to complete the final operations of the rams. This is done by having the piston (*e*) operated by the piston rod (*f*) which passes through a supplementary or hollow rod (*g*) and has an appropriate handle for operating the piston within the pump cylinder. By these means the piston may be quickly reciprocated by the user moving the small handle until the desired quantity of water has been supplied or until the pressure to be exerted over the rod (*f*) is beyond the power of the user, when the supplementary rod (*g*) may be brought into use to finish the operation, this advancing by screw motion, and great pressure being obtainable in this way.

Method of Working.—After the rock or coal has been prepared with one or more loose sides and the drill hole of 3 inches, 3½ inches, or 4½ inches, has been drilled to a suitable depth (say three or more feet), the cartridge is pushed in with liners if necessary. The water tank is filled and hung on the pipe, the rubber suction pipe coupled, and the taps turned. The small handle and then the large one are operated as already described. The pressure being fully on, the enormous power of the apparatus is soon apparent, for the rock or coal is heard to

Fig. 4.—Effect of hydraulic cartridge on rock in mines.

be rumbling and cracking. This is allowed to continue until the breaks are of such a size that the mass can be pushed or pulled over and usually is in such condition as to be easily and safely handled.

Line of least resistance.—It is easy to understand that when a shot is fired in rock or concrete, the direction of the breakage will be chiefly in the line of the weakest part. If the material is of uniform strength this direction would be a straight line from the explosive to the nearest unsupported edge. But stratified beds, seams of coal, and walls of stone or brick, are not usually of uniform strength; rock and coal beds contain breaks, cleats, and faces, while concrete beds are invariably irregular in constitution or structure. It follows, therefore, that the line of least resistance is not necessarily the shortest line from the charge to the surface. The difficulty and danger of explosive firing is that whatever this line may be, it is not often possible to make use of it; the pressure generated, though not equally effective, is equally applied in all directions owing to the instantaneous character of the decomposition. This involves high temperature in the explosive gases, a large portion of the heat being absorbed and wasted in the portions which are not capable of being blown down. When mechanical means are employed the time involved in the operation allows the whole of the power to be exerted and applied in the desired direction without waste of heat energy. Not only is power lost in heat energy in the case of explosive compounds, but the result often proves that there has been counter action whereby the rock displacement is reduced through one line of force operating against another, closing in or reducing the area of broken ground.

In practice it is found possible so to arrange the hydraulic cartridge holes as to enable much greater areas of material to be moved than could be done with a safe quantity of explosive, while in some cases the displacement has been greatly extended by the use of small-sized bore holes toward which the slowly developing line of least resistance can assert itself. In other words the power exerted by the rams can be controlled, after a little experience, so that the full pressure can be usefully applied.

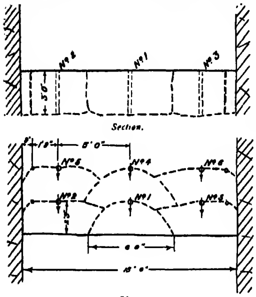
Use in Mines.—The appliance was originally introduced into mines in order to supply the acknowledged need of a different method for bringing down coal in mines in the best possible condition after it had been undercut by hand or machine. The use of high explosives for this purpose, apart from the element of danger, has

* From the *Journal* of the British Society of Engineers.

always been considered undesirable by mining experts, because in using them coal is shattered and wasted and dust made. Now that coal has to be won from greater depth than formerly, and the distances and areas underground increase, the dangers and extent of explosion have proportionately increased, as many recent colliery disasters have shown. The mines in which the cartridge has been chiefly adopted may be divided into two classes:

(a) Where the coal is so friable as to render the use of explosives impossible for commercial reasons.

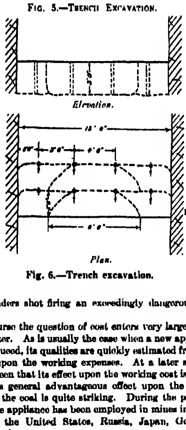
(b) Where the condition of the mines in regard to gas,



Section.

Plan.

Fig. 5.—Trench Excavation.



Elevation.

Plan.

Fig. 6.—Trench excavation.

etc., renders shot firing an exceedingly dangerous proceeding.

Of course the question of cost enters very largely into the matter. As is usually the case when a new appliance is introduced, its qualities are quickly estimated from the effects upon the working expenses. At a later stage it will be seen that its effect upon the working cost is slight, while its general advantageous effect upon the selling price of the coal is quite striking. During the past ten years the appliance has been employed in mines in Great Britain, the United States, Russia, Japan, Germany and Austria.

In removing coal a series of holes is drilled in the top of the seam, adjoining and running parallel with the roof. These holes are at intervals determined by working conditions, usually from 6 feet to 10 feet apart and from 3 feet to 5 feet deep. The operator begins at the first hole and pumps off each in succession, usually leaving the supporting sprags to be removed by the collier, who fills the coal thus broken and prepares the coal behind for a repetition of this process. One operator can pump from 30 to 40 shots per working shift of eight hours, using only one machine, which lasts with repairs from three to four years. This procedure is adopted where a large wall of coal has been opened out, and where the coal is got in pillars and headings the process is somewhat modified. The coal across the face of the heading is undercut (almost universally now by a percussive machine operating from a fixed standard) and a vertical slot or "shearing" is cut up the center of the coal, thus providing a loose end. One hole on each side of the "shear" is then sufficient to bring down the coal. The holes are placed as near as practicable to the fast side in order to bring the coal down as near the "fast-corner" as possible. (Figs. 3 and 4 show the cartridge in use in mines.)

Among the mines in which these machines are at present in use are the following:

Colliery No. 1.—At this colliery an average of over 1,000 explosive shots per week were formerly fired in coal in the various mines. By the introduction of the hydraulic cartridge the whole of the explosive shots have been discarded and there is not now a single shot in coal in any seam. In one seam alone a total of 28,500 hydraulic cartridge thrusts were made in one year, by which it is estimated that 92,626 tons of coal were produced, or about 3¼ tons per thrust. The seam was 3 feet thick and four cartridges were in daily use.

Colliery No. 2.—In a seam using five hydraulic cartridges 450 tons of coal are produced per day, of which 75 per cent is large coal and 25 per cent small. When the coal in this seam was brought down by explosives the percentage of large coal was 65 per cent and the percentage of small was 35 per cent. The average price of large coal was 13s., and of small coal 7s. per ton. The profit obtained by the use of the cartridges on this seam on 450 tons is therefore £14 5s per day. Fifteen machines are employed at this colliery, making a total advantage over explosives of £42 15s. per day. Moreover, an extra 6d. per ton is obtained for the coal brought down with hydraulic cartridges, on account of its greater hardness and freedom from dust.

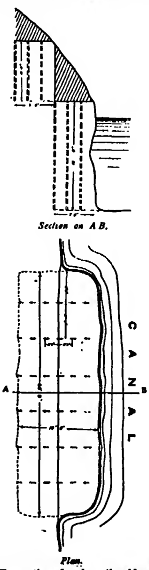
Use in Reservoirs, Docks, Harbors and Canals.—The operations in these places have all certain features in common which allow of their being classed together, and they may be divided into three classes.

(a) *In open Trenches.*—The difficulty of removing rock from confined spaces where it is necessary that no shock or vibration should be transmitted to surrounding strata is a very vital one. The introduction of the hydraulic cartridge into this class of work will, it is hoped, help to solve this question. During the past few years it has been thoroughly tested under most varied conditions and in all classes of deposits.

The work in trenches usually proceeds as follows: A number of holes are drilled (Fig. 5), say 2 feet 3 inches back from the edge of the rock, about 5 feet apart and 3 feet to 5 feet deep, according to circumstances. The holes are, when possible, bored by a power drill operating from a tripod. By these means suitable holes, of diameters up to about 5 inches, can be quickly drilled. The center hole is pumped first and provides a loose end for those on each side. These are pumped in turn until the fast side is reached, where it may be found advisable to drill a small 1-inch diameter hole, say 9 inches from the fast side, to enable the cartridge to break the rock as close to the fast side as possible. Sometimes this method is varied by pumping off two center holes simultaneously and placing the last holes 2 feet from the fast side, leaving out the small diameter holes. (Fig. 6.) In this case the holes could be 2 feet 6 inches from the front edge and two machines would be required.

Taking a trench 15 feet in width and holes 3 feet in depth, the first method would necessitate three cartridges and two 1-inch holes to get 100 cubic feet of rock, while the second method would require only four cartridge holes to remove 112 cubic feet. During the operation of the machine it is possible to see the rock slowly fracturing at each turn of the handle. Work of this character has been done by the cartridge in connection with the Derwent Valley Water Works, and the Cwm Taff Reservoir, Liverpool Corporation, and tests are now being made for the Abertillery Water Scheme.

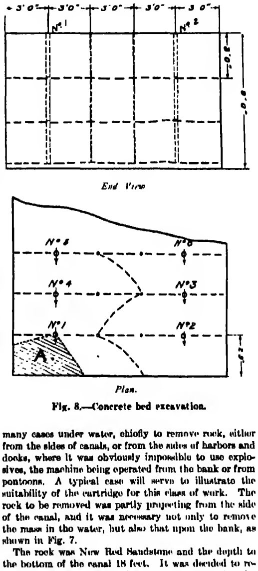
(b) *Under Water.*—The appliance has been used in many cases under water, chiefly to remove rock, either from the sides of canals, or from the sides of harbors and docks, where it was obviously impossible to use explosives, the machine being operated from the bank or from pontoons. A typical case will serve to illustrate the suitability of the cartridge for this class of work. The rock to be removed was partly projecting from the side of the canal, and it was necessary not only to remove the mass in the water, but also that upon the bank, as shown in Fig. 7.



Section on A B.

Plan.

Fig. 7.—Excavation of rock on the side of a canal.



End View

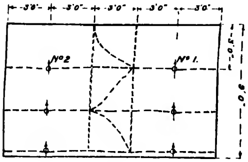
Plan.

Fig. 8.—Concrete bed excavation.

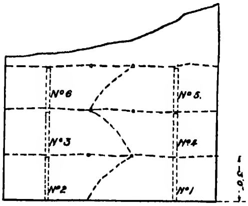
The rock was New Red Sandstone and the depth to the bottom of the canal 18 feet. It was decided to remove the mass the full depth at one operation. A series of holes was accordingly drilled 6 feet apart, 2 feet 4 inches back from the edge, and 18 feet deep. These were pumped off in succession and the operation of the cartridge at this depth sufficed to break the rock right up to the bank in nearly every case. In one or two holes it was found necessary after operating in the bottom half to draw the machine up about 9 feet and operate again. During the operation divers were below water ascertaining the position and extent of the breaks and directing the operator above as to how to continue the thrusts. The portion shaded (Fig. 7) was removed by hand, and another series of holes was put down 10 feet deep, 6 feet apart, and 2 feet 4 inches from the edge, to break up that portion of the rock to be removed.

In the Alexandra Docks at Newport, and in the new dock at Swansea, the appliance has been used to break up ledges of rock occurring in the vicinity of walls which would have been damaged by the use of explosives. The holes were put in and the cartridges inserted under water by divers and pressure was applied from the pump placed on a raft on the water.

(c) *Dock or Harbor Walls.*—Hydraulic machines have been used for some years at the Dover Harbor Works for the purpose of detaching the large concrete blocks used in the harbor walls. These blocks are of great size and weight. By inserting the drill hole along the bottom of the block and placing the cartridge about half-way under it, the whole mass is slightly lifted and tilted without breaking, and being thus released from its bed is easily lifted on to a wagon by a crane. Machines are being used for a similar purpose in other docks.



End View



Plan.

Fig. 9.—Concrete bed excavation.

Excavation of Foundations.—The question of the removal of concrete foundation beds by a method which would not involve explosive blasts and would avoid the slightest damage to machinery or buildings has been carefully studied recently by the writer, and had never been thoroughly solved until extended trials in all parts of the British Isles had been made.

The effect of powerful hydraulic pressure upon concrete is interesting. In the case of sandstone and shales there is comparatively slight crushing of the rock before the full pressure of the rams has the effect of causing the mass to bend; considerable pumping and consequent travel of the rams is then necessary before the rock finally begins to crack and break away; with concrete, however, there is usually a perceptible interval during which the rams are crushing or compressing the material and no movement is noticeable; after this is accomplished a few more thrusts of the rams cause the whole mass to break up without any indications of bending. It may still be necessary to continue to apply pressure and to increase the size of the breaks in the mass, but the greatest shattering effect will have been accomplished at the first disclosure of the cracks, the pressure required to break the mass afterwards gradually diminishing.

In such material, explosives invariably have the effect of "hacking a way through" by the shortest direction to the unsupported edge (Fig. 8), pulverizing the mass but failing to take advantage of pressure gently applied, by means of breaks which spread and widen, and to utilize the weight of the concrete itself to increase the scope of the operation. Numerous experiments in this class of work show that 60 to 70 cubic feet of concrete can easily be removed per thrust.

The general procedure in attacking beds of concrete may be divided thus:

1. By vertical cartridge holes.
2. By horizontal cartridge holes.

1. *By Vertical Cartridge Holes.* (Fig. 8.)—This method is most applicable to places where power can be easily obtained to bore the holes by tripod and power drills. The cartridge holes are drilled about 3 feet deep and 2 feet 9 inches back from the front edge of the bed. It has been found of great advantage to drill small diameter holes 3 feet away and in line, to which the fracture will break. In this way a bed 15 feet wide could be broken all across by two cartridges and two small diameter holes, amounting to 124 cubic feet of material.

2. *By Horizontal Cartridge Holes.* (Fig. 9.)—In this case the holes would be 3 feet deep and made to lift 3 feet of material per thrust, the vertical small diameter holes being put in as before. The amount of material moved per thrust is 67 cubic feet. The effect of lifting up is to break a larger quantity of material and in much larger pieces than is the case with vertical holes. With the latter the concrete is found to be very well broken up, and ready for handling without the further use of tools. Horizontal holes, on the other hand, are more suitable for beds where foundation bolts are embedded in the concrete.

There appears to be no class of work so suitable for this machine as the removal of concrete beds. The following recent case is a typical example. At a municipal electricity works the cartridge was used to remove the main engine room foundation bed. Within a radius of 40 yards from the scene of operations, many of them within the same building, were very valuable Lancashire and water tube boilers, electrical and steam engines and the main switch board and cables. Needless to say the work had to be carried out with as little vibration or shock as possible. Explosives were out of the question, and the ordinary method of hammer and wedge would have proved an extremely long, tedious, and expensive process. The bed consisted of a solid mass 14 feet 6 inches wide, 26 feet long, and 10 feet deep, composed of hard cement concrete for the most part, and reinforced with numerous foundation bolts.

It was considered unnecessary to install power drills on the work and the holes in consequence were drilled by hand. The majority of these were horizontal and were put in by means of an ordinary twist drill and ratchet machine by two men. These men could drill fairly easily 3 feet per hour. One hydraulic cartridge only was employed. The general procedure was to keep the drillers at work putting in holes all round the side of the concrete, the machine following when two or more holes were ready. The holes were on an average 6 feet 6 inches apart, and from 2 feet 6 inches to 3 feet below the surface in the case of horizontal holes. The vertical holes were drilled only in special places to trim down the vertical edge, and in these cases the measurements were about the same. The employment of shot holes to form a breaking point was considered unnecessary. (Fig 10 is a photograph of one of the horizontal shots.)

The debris thus broken was removed by a gang of six men who were kept busily employed with pick and shovel, and wedges were necessary only to break up the larger pieces to a suitable size for handling. It was found that the amount of material broken up in the course of three or four shots was quite sufficient, in consequence of the limited and cramped working area, to keep the men busily employed for the rest of the day. Had it been possible to place more men on the bed, there is no reason why a much better output should not have been attained, but in this case it would have been necessary to break open the wall in several places, which was not considered advisable. The whole bed, weighing approximately 200 tons of concrete, was removed in twenty working days. About sixty shots were necessary to complete the work, making an average of nearly 3½ tons per thrust.

The cost of the work was as follows:

Labor per day, including operator, drillers, navvies, and foreman £2 15 0
Amount of material removed—average 10 tons per day . . . 4 9 per ton.

The above cases will be sufficient to show that with a mechanical substitute for blasting capable of exerting a total pressure of 150 or 200 tons upon rock, coal, concrete, masonry, etc., and in such manner as to cause no shock to the material in which it is operated, there should be possibilities of usefulness to engineers not previously contemplated.

Replying to the discussion, the speaker said that one speaker had referred to the use of black powder for blasting salt rock. That was really in line with the use of the hydraulic machine, which operated slowly and gradually. The old-fashioned explosives had the very distinct advantage that, owing to the length of time required before the gases attained their full temperature and pressure, it was possible to get the power exerted in a more effective way. He thought that if it were not for the element of danger associated with black powder, all users of explosives would agree that the old-fashioned slow-working explosives had always been most satisfactory. It was only carrying the principle a little further to apply it in the form of hydraulic power.

With regard to Mr. Jenkins' point, rotary drills had been used for making holes on many occasions, and it had been found that the diamond drill was quite satisfactory when used as a hand machine. It was very necessary to have a regular and smooth hole, and the diamond drill gave such a hole much better than any percussive drill could possibly do. It appeared to him that it would also have the effect of greatly reducing the amount of dust that would be made in the drilling of the hole, and not only would there be a smaller quantity of dust made, but that dust would be of coarser texture.

As to the driving of headings, he must say that in ordinary tunneling he had not been entirely successful, chiefly because of the difficulty of obtaining a suitable drill for putting holes in easily and quickly. It was not possible to blast from the solid. If the rock was to be broken with a loose end at all, it was necessary to be able to put in small holes readily and easily in various directions. Having loosened one side, there was then no longer any difficulty.

With regard to the limit of 150 to 200 tons, he mentioned those amounts because they were approximately those to which he had worked up to the present. By using the 3-inch machine he got, with full pressure on, about 120 tons. When using a 4-inch machine he generally used about five pistons instead of eight, and he got 170 or 180 up to 200 tons pressure with that particular size. There was no limit. It was possible to increase the pressure according to the length and size

Fig. 10.—Hydraulic cartridge used in a bed of concrete.

of the machine, but there would arise a liability for the cartridge to become bent. There was no bending of the cartridge if the sizes of the machines used were limited as at present, provided that a regular hole was obtained. If the hole was not regular and smooth there would be the risk of some damage being done to the machine. He did not mean to say that there was a danger of bending the machine after the material had once been broken. When the back of the material was broken there was no danger to the cartridge. Very few machines had been bent or damaged in any way. That was probably due to limiting the length of the cartridge to 20 inches in the case of eight-piston machines and a few inches less in the case of a five-piston machine.

With regard to varying the intensity of the pressure, he thought that that was hardly necessary so long as the hole was drilled sufficiently deep. He did not like to have the end of the cartridge anywhere near the end of the hole. It should be right in. As long as it was right in the hole there did not seem to be any advantage to be gained by varying the pressure. He got the cartridge right into the hole, and then it was not necessary to make any change. Usually the pistons were out an equal distance throughout the full length of the cartridge, showing that the resistance had been the same throughout its length.

The Flight of a Golf Ball

Some interesting statements concerning the flight of a golf ball were made in a case heard by Mr. Justice Warrington in the Chancery Court. The validity of the patent granted to William Taylor for his golf ball was challenged by Messrs. A. W. Gamage, Ltd., who claimed the revocation of the patent owned by Charles Stuart Cox and A. G. Spalding & Bros., who made the golf ball under the name of the "Dimple." In the specification of the patentee, he said his principal object was to obtain better results in the flight of the ball in the direction of a sustained hanging flight, giving a flat trajectory, with a slight rising tendency toward the end of the flight.

Prof. C. Vernon Boys said the form of the surface of the ball affected the flight very materially, and, from general experience, a smooth ball had been found not to be so good as one of which the surface had been roughed. The smooth ball had not an advantageous surface for getting a long travel. The character of marking which constituted Taylor's invention was an inverted bramble pattern, and consisted of isolated cavities, circular, evenly distributed, shallow, and their sides steep. Prof. Boys said he found by experiments that this form of surface gave an extremely satisfactory flight. The experiments consisted in driving the balls by means of a machine designed by himself and Mr. Taylor, and were carried out on Borstall Golf Course, on the road to Charnwood Forest. He did not find in the specifications of Willie Park and Fernie, on which Messrs. Gamage relied, Taylor's form of cavities.

In cross-examination as to the typical golf ball's flight, witness said the ball more than counteracted the action of gravity. His Lordship: The golf ball does not make a parabola? Prof. Boys: Not in the slightest degree; a good flight is very nearly straight for a long time, and then gradually rising and then falling. His Lordship, giving judgment, said that the main feature of the descriptive part of Taylor's specification was its vagueness. He held that the patent failed, and that there must be an order for its revocation. A stay was granted pending an appeal.—From the *English Mechanic.*

Snow Removal*

Report of the Conference Held in Philadelphia, April, 1914

EARLY in March, 1914, Mr. Morris L. Cooke, Director of the Department of Public Works, Philadelphia, wrote to a number of the leading eastern cities suggesting the needs of a conference on the subject of snow removal and pointed out, that in view of the very apparent lack of engineering methods generally employed in a problem which so clearly calls for engineering study, it might be profitable if those in charge of the matter of snow removal in the larger cities could be brought together, and that at least an approximation of a definite policy of snow removal might result from such a meeting. The suggestion met with such favor that a snow removal conference was held in Philadelphia on April 16 and 17, 1914.

A Committee on Resolutions, J. W. Paxton, chairman, was appointed to submit a report, which would be the result of papers, discussions and recommendations made at this conference, and the committee makes the following report:

The problem of snow removal must obviously be considered differently in different cities as its solution is dependent upon such variable elements as climate, population, width of streets, density and character of traffic, location of sewer systems, available disposal places and other local conditions, to say nothing of the financial policy of the municipality.

It would seem impossible to formulate anything but the most general suggestions, and yet it is found that even so vital a matter as the financial policy does not affect the main problem, except in the extent of the work.

The work of snow removal is generally done by contract under the supervision of city officials, payment being made according to the quantity removed as tallied by wagons hauling to the disposal dumps, the forces and equipment consisting of men with shovels, horses and wagons. In some cities, scrapers and plows are used to push the snow to the side of the street, relieving traffic and making it easy to pile, or to load without piling.

Salt is generally and very extensively used for the removal of snow in Liverpool, London, Paris and other European cities. The very general practice is to broadcast coarse salt on the streets during and immediately after a snow storm, and when the snow has been reduced to slush by the action of the salt, the streets are flushed with water and the slush washed down the sewers; but in those cities they do not have very heavy snows and it is doubtful whether it would be practicable here where we have a much greater depth of snow. There is also a very serious objection to the use of salt by the Societies for Prevention of Cruelty to Animals and in some of the cities it is prohibited by ordinance. It is questionable whether the use of salt has been given a fair trial in this country for the removal of snow and there is little doubt but that it would be useful in light snow storms.

Much thought has been given to the design of apparatus for melting snow, and also, to special machinery for scraping, loading and transporting. Inventors, designers and manufacturers should be encouraged to continue in the endeavor to produce equipment which will render practical and efficient service, but the amount of snow is so variable and the equipment is in use for such a short period of time that it is desirable it be designed to be useful for other work at different seasons of the year.

The problem confronting the public officials is the removal of snow in the shortest time in such a manner as not to interfere with traffic, and at a minimum cost. Therefore, using the method of scraping, shoveling into trucks or carts and hauling to dumps, the length of haul becomes a most important factor and it can readily be seen that the utilization of sewer manholes as dumps, and the sewer system to carry the material to the rivers, is the most economical method which can be devised as it reduces both the haul and the handling to a minimum. The authorities in charge of the sewer systems have, as a general thing, apprehensions regarding the use of the sewer as a snow carrier. The Borough of Manhattan, New York, Bureau of Sewers, however, made experiments during the winter of 1914 which seem to prove that, within certain limits, such apprehensions are ill-founded.

Gas and chemical combinations in the sewers have little effect on the rate of melting. Two cubic yards per minute is the maximum rate at which snow can be shoveled into a 24-inch manhole. Tidal sewers can only be used to advantage when the tide is low, in which case the factors of the ordinary sewer apply. Siphon sewers can be used as well as the ordinary type.

Where difficulty is experienced with an insufficient flow in the sewers, or where the flow decreases or stops, the water plug may be opened in the drainage area of the sewer above the manhole in use, until the volume of water is sufficient to carry off the snow, but it has been found that the most efficient use of water may be had where water jets are constructed in the manholes into which the snow is dumped. The problem of getting the material into the manholes in the least time with the least interference with traffic opens up a field for the consideration of a special form of manhole to be used satisfactorily for this purpose. Pittsburgh and St. Louis both use a special form of manhole.

The committee gave further an account of the work of snow removal in the cities of Philadelphia, New York, Boston and Scranton, and also of the Public Service Railway of New Jersey, and the Pennsylvania Railroad Company, on which they base the following conclusions:

1st. The plan of organization and the system to be employed should be worked out in advance of the snow season. This preliminary work should involve: (*a*) a plan of co-operation among all branches of the municipal government; (*b*) the formation of a skeleton organization composed of all the available city forces, such as engineers, inspectors, time-keepers, laborers and teams; (*c*) the division of the city into zones and the determination of a definite method of work for each zone. The various members of the organization should be assigned to these zones and the responsible officials familiarized with the duties expected of them.

The character of work to be performed in the different zones may consist merely of the regulation of opening cross-walks and gutters and otherwise generally assisting pedestrian traffic and the run-off of the snow, or it may consist in the complete removal of the snow from the streets. Owing to the general increase in motor traffic and the concentration of business in definite office districts and to the general public demand for increased urban facilities, the present tendency is to increase the scope of the work involving the complete removal of snow from all main thoroughfares and business streets.

2nd. Removal work should commence as soon as the snow has covered the pavements and the indications point to the storm continuing, and should be carried on continuously. This as a principle is successfully followed by street railways and by some cities.

3rd. The carrying capacity of the sewer system should be utilized as far as possible.

The use of the sewers which reduces both the haul and handling to a minimum involves two operations: namely, getting the material to the catch basins or manholes, and then putting the material into the sewers. The first operation can best be done by loading into wagons or trucks and hauling to suitable manholes or by the use of scrapers or graders. The problem of getting the material into the manholes in the least time and with the least interference with traffic opens up a field for consideration of the question of special forms and special locations of manholes designed to be used solely for this purpose.

The method of flushing the snow with fire hose into catch basins may have a limited application but it is too unreliable to have any general value as it depends on weather conditions.

4th. When practicable, where there is only a small area to be cleaned, the work should be performed directly by the municipality by day labor. This method of operation is the most flexible and the most easily administered and it obviates the necessity of measurements and checking involved under the contract system. The work can also be performed by day labor in large areas by adopting the following method: The department to advertise and go out into the open market and hire teams to haul the snow for so much per yard, the price to be determined by the department and to represent a fair estimate of the cost of the work and a fair profit. This, of course, would throw the work open to anyone owning one team, or a hundred or a thousand or more teams, depending upon the amount of work to be performed, and would not leave the department dependent upon any one or more contractors. In this method, as well as when the work must be performed by contract system, a method of measurement as simple and accurate as possible should be used. The practicability of having work done by the municipality will depend among other things on the immediate availability of an appropriation. It is essential for the proper conduct of the work whether by day labor or contract that appropriation for snow removal should be made in advance of necessity for the work.

5th. Co-operation should be sought with the traction companies and use made of adjustable plows and sweepers to open roadways adjacent to street railway tracks at the time that the work of clearing the tracks is being carried on.

6th. Effort should be made to obtain the co-operation of the public and to instruct the householders in the method of the removal of snow from private premises in such a way as to least impede the city's work. Where sidewalks are of greater width than would be necessary to handle the reduced volume of pedestrian traffic, which may be expected after a heavy snow, the snow instead of being entirely cleared from the sidewalk and piled in the roadway should be left on the sidewalk near the curb line to be later removed by the city when opportunity presents itself.

7th The police force of the city should co-operate with the street cleaning force and the services of patrolmen as inspectors should be utilized as far as possible. The police in particular should give attention to the enforcement of regulation governing the removal of snow from the sidewalks or from a portion thereof.

In a written discussion Mr. J. T. Fetherston[1] remarked that New York City has tried almost every method of contracting for snow work, from the area system to the direct haulage method on vehicle capacity basis Dividing the city into relatively small districts, larger districts and boroughs has been tried, and it would appear that the responsibility and experience of the contractor were of greater importance than the area or district assignments. In other words, an experienced contractor, with the nucleus of the necessary snow removal equipment, as a rule is in better shape to remove snow rapidly and control sub-contractors than is the municipality. More important still, he usually has sufficient control of funds to pay promptly all men employed. It would seem that experience, control of equipment and responsibility are the main factors to be considered, rather than the area basis, for the assignment of contracts

The statement of general principles contained in the committee's report would be clarified if the work were separated into these divisions. (1) contract work, (2) street railway assignments, (3) municipal work Necessarily under each head should be given the plan, and every reasonable contingency covered by the assignment of the most suitable means of snow removal adapted to particular areas, streets or districts of the city under consideration. All municipal departments should be called in to assist the street cleaning division by the assignment of officers for the supervision of contract work particularly, leaving the street cleaning department as free as possible to perform the work for which its own force is best fitted.

As a general comment on the committee report, it is suggested that, if possible, engineers or street cleaning officials should receive from an authoritative source, such as the society, a summary of conclusions covering:

(1) A statement as to what types of streets should be cleared of snow, and how far the municipality is justified in removing snow from minor thoroughfares at public expense.

(2) A statement setting up the reasonable depth of snow for which a municipality should have equipment available, and in general the time limits within which streets should be cleared, so as to avoid economic loss. Coupled with this, a maximum depth of snowfall beyond which all citizens and transporting agencies should be required to place their services at the disposal of the municipality at cost.

(3) A compilation of snow statistics for various parts of this country, and if possible a summary of attending weather conditions.

Each city must work out its own salvation regarding snow removal and disposal methods. The problem is so complicated by uncertainty as to weather conditions that no particular method is best fitted for all cities and all conditions.

E. D. Very,[2] in a written discussion, pointed out that an endeavor should be made to define the extent to which snow removal should be carried on in a municipality. This definition should not be made in units of mileage or of square yardage but rather in terms of necessity. In this regard the financial policy so affects the main problem as to deserve considerable study, as the extent to which the work shall be carried on depends largely upon the amount of money a municipality can afford to spend. This question must be answered before we may assume that the area to be cleaned has been decided upon and the appropriation of money must be predicated upon an understanding of the actual need in this regard. We should go further and discuss the manner in which funds for the work should be raised.

* From the Journal of the Am. Society of Mechanical Engineers.

[1] Commissioner, Dept. of Street Cleaning, New York.

[2] Sanitary Engr., New York

It is suggested that the tax for such purpose should be levied; a part by a general tax and a part by tax on property immediately benefited. Such a method would restrain the indiscriminate demand for unnecessary service for personal benefit.

W. Goldsmith[1] called attention to a statement in the report where mention is made of enlarging manholes for the quick disposal of snow. In the Manhattan experiment it was shown that two cubic yards of snow per minute can be shoveled into a 24-inch manhole and that 2,560 cubic yards were dumped into one sewer by means of three manholes in an 8-hour day. This seems to indicate that a 24-inch manhole is large enough. Besides, the effect of an enlarged manhole on the pavement must be considered, the majority of defects in street surfaces being due to manholes of one nature or another and it seems that the elimination rather than an increase of these enemies to pavements should be striven for.

F. Kingsley pointed out the fact that the same old cart-and-horse methods for snow removal seem to be used that were adopted when the problem became serious some 20 years ago. It is interesting, however, to note the success of the snow-melting device on the Pennsylvania Railroad, because the melting of snow seems to be the most likely path along which improvement can take place.

The cost of fuel to melt snow is only some 15 per cent of cost of handling it under present methods. The basis for this is that a cubic yard of snow as removed weighs approximately 1,000 pounds and would require about 200,000 British thermal units to reduce it to water, allowing a liberal margin over the latent heat of ice. Coal at $4 per ton provides about 67,000 British thermal units for one cent in a perfect furnace, or 27,000 British thermal units with 40 per cent furnace efficiency. At the latter rate the fuel cost for melting would only be 7½ cents per cubic yard or 15 per cent of the present apparent cost of handling it. This does not include interest or labor charges but these ought not to be insurmountable obstacles.

The problem is peculiarly one that mechanical engineers should be able to solve. It appears to be largely a balancing of the cost of heating surface against interest charges, and 1 square foot of heating surface can transmit heat (as demonstrated by existing locomotive boilers) at an approximate rate of 20,000 British thermal units per square foot per hour. With less efficient but more rapid transmission, twice this rate does not seem impossible. On this basis, apparatus capable of melting 100 cubic yards of snow an hour would require 500 square feet of heating surface. Certainly there is nothing abnormal involved in the provision of heating surface in such amounts as this.

One hundred cubic yards of compacted snow appears to be equivalent to about 450 cubic yards of snow as it falls, and in a 3-inch snowfall this amount would cover 500 linear feet of street. The subject obviously seems to be one that is worth consideration by the various cities in the country. It would be interesting to see some thoroughgoing experiments along this line.

The Protection of Iron and Steel by Paint Films*

By Norman A. Dubois

The theories of corrosion of iron and steel which have received consideration and which still seem to have their defenders and opposers are interesting to note. The carbonic acid theory in brief requires the presence of carbonic acid to start corrosion. The peroxide theory supposes that hydrogen peroxide is formed in the presence of moisture and oxygen, and that this hydrogen peroxide causes corrosion. The electrolytic theory assumes that iron passes into solution in water in the form of a ferrous ion before it can oxidize. A more or less complete discussion of these theories may be found in the various journals and other publications. It is not the purpose of this paper to discuss them.

From the standpoint of the paint technologist the problem is that of finding the paint film which will enable him to protect the exposed surface of iron and steel from the various rusting influences for the longest possible time. The theories of corrosion and numerous discussions of them have been of inestimable value, and the proper interpretation of them has enabled the paint technologist to improve his paint film. Let us briefly consider these theories from the standpoint in question.

The carbonic acid theory requires the presence of carbonic acid that corrosion may proceed. In other words, considering a paint film properly applied over the surface of iron and steel it requires that carbon dioxide shall pass through this film, and also that water, either as such or in the form of aqueous vapor, shall pass through the film, and there in conjunction with the carbon dioxide react as carbonic acid. The imperviousness of the paint film to carbon dioxide gas and to aqueous vapor, then, is the vital quality from the standpoint of this theory. The more impervious the paint film to the gases carbon dioxide and aqueous vapor, the longer it will protect the iron or steel from corrosion.

The peroxide theory requires the formation of hydrogen peroxide on the surface of the iron or steel. Considering a paint film properly applied over the surface of iron or steel, therefore, this means that the less pervious the paint film is to the gases oxygen and aqueous vapor, the smaller will be the quantity of hydrogen peroxide formed on the surface of the iron or steel, and the longer it will protect the iron or steel from corrosion.

The electrolytic theory requires that iron first pass into solution in water as ferrous ion, and that it is then acted upon by oxygen dissolved in the water or by carbon dioxide and water to form rust. Again considering a paint film properly applied over iron or steel this theory requires the presence of water in which the iron may dissolve to form ferrous ions. Obviously, the only way the water can get to the iron or steel is to pass through the paint film, as such, or in the form of aqueous vapor. If we suppose the ferrous ions have been formed, the action can go no further in the absence of an oxidizing agent, presumably oxygen, which in turn must get through the paint film. The reasoning for the presence of other gases is similar. We find, therefore, that for corrosion to proceed according to the electrolytic theory the gases, aqueous vapor, oxygen, or others must pass through the paint film, and, as in the other cases, the more impervious the paint film to gases and moisture, the longer it will protect the surface of the iron or steel from corrosion.

This is but to conclude that the paint film which will serve for the longest time as a protection to iron or steel against corrosion is the one which is the least pervious to aqueous vapor, the gases oxygen and carbon dioxide, or in fact any gas in the surrounding atmosphere which may in any way cause or accelerate corrosion.

If we assume the corrosion to be entirely due to the deterioration of the paint film rather than to its permeability to aqueous vapor and other gases, the same conclusion holds, as the rate of deterioration will be proportional to the permeability of the film to the deteriorating elements.

The electrolytic theory of corrosion has given rise to a division of pigments into three classes: corrosion accelerators, corrosion inhibitors, and inerts. While these pigments seem to give results as predicted by this theory in the presence of an abundance of water or when the iron or steel is actually immersed in water, it does not necessarily follow that they will do so, to a like extent at least, when incorporated in a paint film where conditions are much different.

Assume, for instance, that our paint film is somewhat pervious to aqueous vapor and other gases. It follows that just as much moisture may enter to the iron or steel surface and perhaps give conditions under which the electrolytic theory may apply when outside conditions are damp, this moisture may also pass from the steel surface outward when outside conditions are dry, and thus leave the steel surface dry, in which case the electrolytic theory cannot possibly apply. As a matter of fact, the actual conditions existing on the surface beneath the paint film, in most instances, are very probably between the two extremes of somewhat damp and nearly dry, and this is far from being covered with an abundance of water at all times, the conditions under which the electrolytic theory seems to work out well. This reasoning is borne out by the fact that a piece of bright steel immersed in water containing a little zinc chromate in suspension will remain bright perhaps indefinitely, while the same pigment in a paint film under ordinary conditions will not protect the steel in a like manner.

Again, two paints composed of the same vehicle, but the first containing a so-called corrosion accelerator only, painted on a steel surface in a locality of ordinary dryness will outlast to a great extent the second containing a rust inhibitive pigment painted on a steel surface in a locality habitually very damp.

This reasoning seems to indicate and the evidence seems to bear out the conclusion that the problem of iron and steel preservation is rather to be solved by making our paint film as nearly impervious to gases as possible than by trying to prevent corrosion by the addition of the so-called inhibitive pigments.

The problem is a physical one rather than a chemical one, and a comparison of paint films as to their relative obstruction to the diffusion of gases will tell more regarding their value as protection against corrosion than a study of the inhibitive action of their pigments. This is not to say that the inhibitive property of certain pigments is not worth consideration, but the imperviousness of the films is of far greater importance.

[1] Asst. Eng., Dept. of Public Works, New York City.

* Reprinted from the *Journal of Industrial and Engineering Chemistry*.

A New Passenger Ropeway

The methods of constructing ropeways have been so thoroughly perfected that large numbers have been built for the conveyance of both passengers and merchandise in various parts of the world and have proved entirely successful and satisfactory. A new installment that has recently been put into operation at Bozen, in Germany, is thus described: The way is 5,400 feet long, with a rise of 2,750 feet, the grade being an average inclination of 43 degrees. The up-and-down lines are located 20 feet apart and each consists of two steel cables, 20 inches apart, on which runs a four-wheel trolley. The cars, of which there are two, each with a capacity of sixteen people, half inside and half outside, are attached to these trolleys, and the two cars are connected by double cables operated by an electric motor located at the highest station. The current is derived from a central station, but there are batteries for use in an emergency, and hand gear is also fitted to the cars, one of which descends as the other ascends. This ropeway is supported on steel towers, the highest one being 50 feet, while the longest span between towers is 1,300 feet.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, MARCH 6, 1915

Published weekly by Munn & Company, Incorporated

Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 361 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876)	per year	$5.00
Scientific American (established 1845)	"	3.00
American Homes and Gardens	"	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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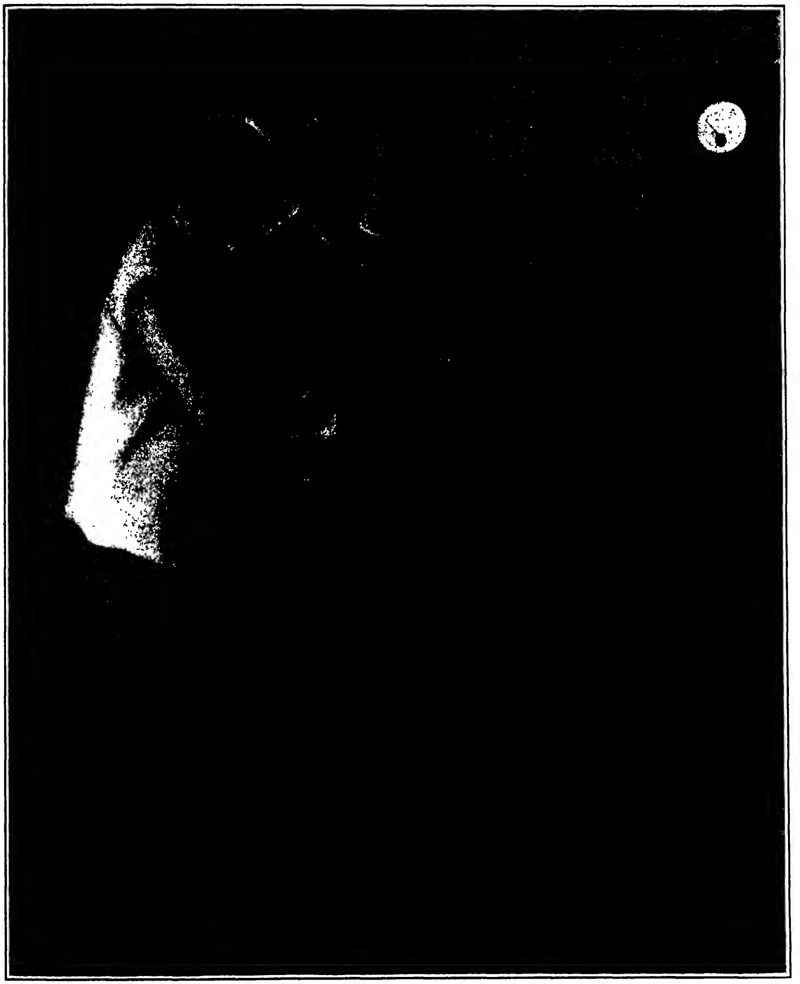
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX NUMBER 2045

NEW YORK, MARCH 13, 1915

10 CENTS A COPY $5.00 A YEAR



REMOVING PARTICLES OF METAL FROM A WOUND BY MEANS OF A GREAT ELECTRO-MAGNET.—[See page 168.]

The Relation of the Horse-Power to the Kilowatt*

Reasons for the Adoption of an Absolute and Invariable Standard of Power

The value of the horse-power may be expressed either in gravitational or in absolute units of power. Confusion often results when one equivalent is reduced to the other, since the gravitational units depend on the force of gravity which varies from place to place and the absolute units do not. Thus the usual gravitational value for the English horse-power, 550 foot-pounds per second, when reduced to watts gives a different number according to the value of the acceleration of gravity employed in the conversion, and hence we find different values in various reference books, of which the following may be cited:

	Watts
Kent's Mechanical Engineers' Pocketbook (1903), page 403	746
Suplee's Mechanical Engineer's Reference Book (1904), page 80	746
Standard Handbook for Electrical Engineers (1908), page [illegible] and (19[illegible]) page	745.6
Foster's Electrical Engineer's Pocketbook, 1908:	
Page [illegible]	746
Page	745.650
Trautwine's Civil Engineers' Pocketbook, [illegible] page 44	745.936
American Civil Engineers' Pocketbook, [illegible]:	
Page 97	746
Page 1[illegible]3	745.7
Hering's Conversion Tables (1904), page 8	74[illegible].650

Such confusion has arisen because there has been no accepted authoritative definition of the horse-power. When the horse-power is taken as a specified number of watts, it represents the same amount of power at all places. But when the horse-power is taken as a specified number of foot-pounds per second, the amount of power represented by it varies for different places. This is evident since the weight of a "pound" as a unit of force, varies in value as g, the acceleration of gravity, varies. Thus, since g is greater for northern latitudes than for southern, the force represented by a definite number of pounds increases as one goes north. This makes this mode of definition of the horse-power very unsatisfactory. It is similar to a proposal once made to define the meter as the length of the seconds pendulum. No one would now consider seriously a unit of length which varies at different parts of the world. Nevertheless, units of force having precisely that characteristic are in common use at the present time. The gravitational system of units centers about the gravitational unit of force, and it is accordingly impossible to understand the subject without careful consideration of the pound and other gravitational units of force. For the attainment of precise numerical relations the value of g must also be carefully considered, and authoritative data on this will be given below.

THE POUND AS A UNIT OF FORCE

The pound and the kilogramme are primarily units of mass. It is convenient to use the force of gravity upon masses to measure forces, so that units of the same names are used for force (or weight) as for mass. The inherence of the acceleration of gravity in these units of force is often forgotten and is the cause of some confusion. The pound as a unit of force has generally been used as a gravitational unit, the characteristic of the gravitational units being that their magnitudes vary with locality as g varies. Thus a pound force is equal to the force of gravity on a pound mass at any place where measurements happen to be made. The one advantage of the gravitational system is that a given mass exerts the same *number* of pounds of force no matter what its location. But by this mode of definition the *magnitude* of the pound force is not constant, as it varies with g. A few writers on the other hand have defined the pound force as a fixed unit, taking it as equal to the force of gravity on a pound mass at some one particular place—e. g., Paris, or 45 degrees latitude and sea level—thus destroying the gravitational character of the unit.

The unit of force can be made definite and fixed, however, without abolishing the gravitational system. This is done by recognizing the difference between the absolute and the gravitational pound by the use of the terms "standard" and "local," respectively. The principle involved is that contained in the definition of "standard weight" by the International Conference on Weights and Measures in 1901. The statement[1] by the conference is given herewith:

The term weight designates a quantity of the same nature as a force; the weight of a body is the product of the mass of that body by the acceleration of gravity; in particular, the standard weight of a body is the product of the mass of that body by the standard acceleration of gravity.

The number adopted in the International Service of Weights and Measures for the value of the standard acceleration of gravity is 980.665 cubic centimeters per second.

By analogy with "standard weight," the "standard pound force" may be defined as equal to the force of gravity on a pound mass at a place where g has the standard value, 980.665 cubic centimeters per second per second, or 32.1740 feet per second per second. Likewise the "local pound force" in any given locality may be defined as equal to the force of gravity on a pound mass in that given locality. Similar definitions apply to the terms "standard kilogramme force" and "local kilogramme force." In specifying a force in local units it is desirable to give the location of the place by such expressions, e. g., as "London pounds," "New York kilogrammes," "local kilogrammes (g=981.26)," etc. This application of the terms "standard" and "local" to the common units of force was proposed by Prof. E. V. Huntington, of Harvard University, and is followed in this circular.

The words "pound" and "kilogramme" used alone as units of force are ambiguous. When so used, the local unit must usually be understood. This has been the usual sense of the terms as used in the past. Such an interpretation is clearly implied in the analogous statement on "weight" by the international conference above. Writers careful enough to use "standard pounds" or "kilogrammes" may be expected to use the word "standard" explicitly, while those who use "pound" without thinking how it is defined will naturally employ the local unit.

The terms here given are readily extended to derived units based upon the units of force. Thus definitions follow at once for "standard foot-pound," "local foot-pound," "standard kilogramme meter," etc.

THE VALUE OF THE ACCELERATION OF GRAVITY

The standard value of g, 980.665 cubic centimeters per second per second, was originally intended to represent the latitude of 45 degrees and sea level. It has been widely used as a standard value for barometric reductions, etc., since 1901, and there is no reason why it should not continue in use as a standard value, although the accepted theoretical value for 45 degrees and sea level is now a few parts in 100,000 different. The exact value obtained for 45 degrees and sea level varies with the gravity observations utilized and also with the theory adopted for the anomalies or departures of the observed values of gravity for any particular stations from the values calculated by a general formula. It is generally conceded to be better to retain a certain value as standard rather than to correct it from time to time to make it agree with a theoretical location. The value 980.665 is the result of a calculation made by the International Committee on Weights and Measures[2] from Defforges' absolute determination[3] of g at the International Bureau in 1888.

In calculating the equivalent of the horse-power in various units for different latitudes the following formula is used:

$$g = 978.038\ (1 + 0.005\ 302 \sin^2 \phi - 0.000\ 007 \sin^2 2\phi)$$

where ϕ is the latitude. This formula[4] is accepted by the United States Coast and Geodetic Survey, and is the result of observations all over the United States with Hayford's corrections for isostatic compensation. It is referred to the absolute determination of g at Potsdam about 1900. The theoretical values given by this formula will not in general agree exactly with the actual values at any particular place because of the local anomalies caused by topography, etc. The departures are in general only a few parts in 100,000. As this formula does not give g=980.665 for ϕ=45 degrees, the point is once more emphasized that 980.665 is an independent standard value not precisely related to a fixed locality.

PRACTICAL NEED FOR AN INVARIABLE UNIT OF POWER

Power is very commonly measured with considerable precision, and hence it is important that the magnitude of the unit should not vary from place to place. From the standpoint of metrology the definition of any unit should be rigorous and free from ambiguity. The necessity for a precise definition exists at the present time in engineering practice. When extensive research is being made upon steam turbines, when tests are made carefully and results are interpreted minutely, there should be no uncertainty in the units used.

A precise definition is desirable even in the commerce of to-day. Misunderstandings might arise over the acceptance or rejection of an engine under test because of the definition of the unit of power. If the power delivered by the engine is measured by the use of a brake with weights, the number of foot-pounds per second observed would be greater, for example, at New Orleans than at New York, since the force exerted by the weights is different for different latitudes and altitudes. Consequently, if the horse-power is defined as a definite number of foot-pounds per second, the same at all places, it is possible that the engine might be accepted if the test were made at New Orleans and rejected if the test were made at New York. These remarks also apply to the case of testing an engine when the force is measured by a dynamometer or an indicator, as well as when measured directly by weights. If the springs were all standardized at the same place, then the variation of the force of gravity would not enter the problem. However, the elasticity of springs varies with temperature, etc., and hence in the making of an accurate test the spring is calibrated by weights at the time and place of the test. Consequently, in any case the variation of the force of gravity with locality must be considered in interpreting the results of a test. The differences here discussed are less than 1 per cent and greater errors than this would be introduced in any practical case by variation in the lubrication, in the measurement of power, and in the quality of steam. Nevertheless, the mean of a series of tests would be taken as the performance of an engine, and if this figure were just on the margin of tolerance an uncertain definition of the horse-power might cause misunderstandings. No such confusion is possible if the horse-power is defined in such a way as to always represent the same amount of power.

On account of the variation with g, and because the equivalents of the horse-power are not decimal multiples of any of the fundamental units, and, further, because its definition and value are different on the Continent of Europe from its definition and value in England and America, it has long been felt that the horse-power is an unsuitable unit for many purposes. Modern engineering practice is constantly tending away from the horse-power and toward the watt and kilowatt. In Germany it has been proposed to call the kilowatt Neupferd (new horse-power) to make its use appeal more strongly to those who have become firmly attached to the horse-power. The objection to the horse-power has been particularly strong in electrical engineering. The International Congress of Electricians at Paris in 1889 recommended that the power of machines be expressed in kilowatts instead of in horse-power. A more definite and powerful action with a view to the elimination of the horse-power was taken by the International Electrotechnical Commission at Turin, Italy, in 1911. This body, composed of the representatives of great electrical interests all over the world, recommended that in all countries electrical machinery, including motors, be rated in kilowatts only.

HISTORICAL

The term horse-power as a measure of the activity of machinery was introduced[5] by Thomas Savery, the inventor of an early type of steam engine. The earliest application of the steam engine was in the pumping of water from mines, work which had formerly been done by horses. Savery, in his *Miners' Friend*, page 29, in the year 1702, says that an engine which will raise as much water as 2 horses working continuously in a given number of hours will do the work or labor of about 10 horses, since relays of horses must be used to keep the work going continuously; such an engine then he called a 10-horse-power engine.

James Watt, who is generally known as the inventor of the modern steam engine, adopted[6] the term horse-power as a unit for expressing the power of his steam engine and defined its value in gravitational units viz: foot-pounds per minute. The magnitude of Watt's horse-power was, however, six or eight times as great as Savery's. The value[7] was derived from experiments made under the direction of Watt and Boulton, his business partner, about the year 1775.

Some heavy horses of Barclay & Perkins's brewery, London, were caused to raise a weight from the bottom of a deep well by pulling horizontally on a rope passing over a pulley. It was found that a horse could raise a weight of 100 pounds while walking at the rate of 2.5 miles per hour. This is equivalent to 22,000 foot-pounds per minute. Watt added 50 per cent to this value, giving 33,000 foot-pounds per minute, or 550 foot-pounds per second. The addition of 50 per cent

*Circular No. 34 of the U. S. Bureau of Standards, Washington.

[1] *Procès-Verbaux des Séances*, Comité International des Poids et Mesures, p. 172, 1901.

[2] *Procès-Verbaux des Séances*, p. 166, 1901.

[3] *Ibid.*, p. 181, 1891. Mémorial du Dépôt Général de la Guerre, 15 (1) 1894.

[4] Special Publication No. 12, U. S. Coast and Geodetic Survey, p. 10, 1912.

[5] "The Life of James Watt," by J. P. Muirhead (London, 1858), p. 188.

[6] John Robinson, *Mechanical Philosophy*, Vol. II (Edinburgh, 1822).

[7] L. P. Church, *Statics and Dynamics* (New York, 1890), p. 136. *Encyclopædia Britannica*, 4th edition, article on "Steam and steam engines," written by John Robinson, with footnotes by James Watt, Jr. T. W. Wright, *Elements of Mechanics* (New York, 1896), p. 256.

TABLE 1

Various Values Adopted For The Horsepower

(Foot-Pounds Given in Terms of the Local Foot and Pound)

	Foot-pounds per second	English horse-power	Kilogram-meters per second	Authority [a]
England and United States	550.	1.0000	76.041	V
Austria (old)	[illegible]	1.0[illegible]	[illegible]	H
Switzerland	[illegible]	[illegible]	[illegible]	A
Sweden	[illegible]	[illegible]	[illegible]	H
Russia	[illegible]	1.[illegible]	[illegible]	H
Prussia	[illegible]	[illegible]	[illegible]	H
Saxony	[illegible]	[illegible]	[illegible]	H
Baden	[illegible]	[illegible]	[illegible]	H
Württemberg	[illegible]	[illegible]	[illegible]	H
Bavaria	[illegible]	[illegible]	[illegible]	K
Modern Germany				
Austria	....	[illegible]	[illegible]	V
France				
Italy, etc.				

was an allowance made for friction, so that a purchaser of one of his engines might have no ground for complaint. The figure thus arrived at by Watt is admitted to be in excess of the power of an average horse for continuous work, and is probably at least twice the power of the average horse working six hours per day.

Since the time of Watt his value has been in general use in England and the United States, and 550 foot-pounds per second is known as the English horse-power. As the use of the steam engine spread from England into other countries the value of the horse-power was translated into the units of the various countries; that is, since the foot and pound had different values in the different countries, the number of foot-pounds in a horse-power necessarily varied. These values were given to the nearest round number, and hence the equivalence to the English horse-power was only approximate, the value averaging about 1 per cent smaller. Hence arose the discrepancies shown in Table I.

After the metric system had come into use in France, Germany and Austria the values of the horse-power in the various countries were reduced to kilogramme-meters per second, with the results shown in the table. The values range from 75 to 76 kilogramme-meters per second, averaging only a little more than 75. Hence, this round value, 75, has been adopted generally on the Continent as the value of the horse-power.

The English value, 550 foot-pounds per second, is, however, equivalent to 76.041 kilogramme-meters per second, and hence it is that there is a difference of nearly 1.5 per cent between the value generally used in English and American practice and that used in continental practice. Reduced to watts, the English horse-power is generally taken as 746 watts, although the precise equivalent, in watts, of 550 foot-pounds per second depends on the acceleration of gravity, and hence on the latitude and altitude. This is discussed fully below.

It is unfortunate that the value of the horse-power on the Continent of Europe was not taken as 76 kilogramme-meters per second instead of 75, in order that it might agree with the English value, as was originally intended. It is perhaps unlikely that a change to 76 could now be made, or that an agreement could be reached by which the continental and the English horse-power would correspond to the same number of watts. It is to some extent customary for continental writers to distinguish the two horse-powers by the words "English" and "metric." We shall call the latter the "continental horse-power." Thus, German writers speak of the "Englische Pferdestärke" and the "metrische Pferdestärke." The term "Pferdestärke" is now the preferred name for the horse-power in Germany, the old term "Pferdekraft" being unsuitable because "Kraft" means "force." Similarly, in France, the old term "force-de-cheval" has been given up for "cheval-vapeur." There is another unit of power which has been used in Europe, the "poncelet," or 100 kilogramme-meters per second. This unit was named in honor of Jean Victor Poncelet, who introduced the teaching of kinematics at the Sorbonne in 1838. This unit was adopted in France shortly before 1846, according to C. F. Peschel.[b] It was adopted as a unit of power in 1889 by the "Congrès international de méchanique appliquée." Its use is still permitted in the electrical regulations issued by the "Association alsacienne des Propriétaires d'Appareils à Vapeur." It has not, however, been much used in practice.[12] This is probably due in part to the fact that the horse-power had so firm a hold as the unit of power, and in part to the very near equivalence of the poncelet to the kilowatt. The poncelet is open to the same objection as the horse-power when the latter is rigidly defined as a certain number of foot-pounds or kilogramme-meters per second, viz., that the power it represents varies from place to place.

[a] V = various. H = Des Ingenieurs Taschenbuch-Hütte II (Berlin, 1908). A = F. Autenheimer, Mechanische Arbeit (Stuttgart, 1871), p. 15. N = J. W. Nystrom, Elements of Mechanics (Philadelphia, 1875), p. 68. K = Karmarsch und Heeren's Technisches Wörterbuch VI (1888), p. 637; and Alexander's Weights and Measures (Baltimore, 1850).

[b] Peschel's Elements of Physics, Vol. II, p. 280 (London, 1846).

[12] [illegible] Lindeck, Physikalisches Gramm.

EQUIVALENTS OF THE ENGLISH AND AMERICAN HORSE-POWER.

It is possible to define the horse-power in such a way that the value determined by James Watt will be continued and yet the unit will represent *the same rate at all places*. The convenient and frequently used equivalent, 746 watts, happens to be equal to the rate of work expressed by 550 local foot-pounds per second *at 50 degrees latitude and sea level*, nearly the latitude of London, where Watt's original experiments to determine the horse-power were made. The horse-power is therefore taken to be equal to the definite amount of power, 746 watts, and in consequence the number of foot-pounds per second corresponding to 1 horse-power varies with the value of g. The number of standard[13] foot-pounds per second in a horse-power = 550.22. The same rate of work is expressed by a larger number of foot-pounds per second in lower latitudes and higher altitudes, where the force of gravity is less, and by a smaller number of foot-pounds per second in higher latitudes where the force of gravity is greater. Table 2 gives the number of foot-pounds per second in a horse-power at various latitudes and altitudes. The value of g at sea level is obtained from the formula previously given. The change with altitude is calculated from the correction to the value of g, viz., −0.000192 per meter elevation. The number given in the table for 45 degrees and sea level is 550.24; the fact that it differs from the number of "standard" foot-pounds per second, above, emphasizes again the fact that the standard value of g does not correspond quite exactly to 45 degrees and sea level.

TABLE 2

Value of the English and American Horsepower (746 Watts) in Local Foot-Pounds per Second at Various Latitudes and Altitudes[14]

Altitude	Latitude: 0° (equator)	30°	45°	60°	90° (pole)
Sea level	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] feet	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] feet	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The foregoing table may be put in the following approximate form for ease of remembering:

TABLE 3

English and American Horsepower (746 Watts) at Various Latitudes

Latitude	Local foot-pounds per second (approx.)
90°, pole	[illegible]
50°, London	[illegible]
(39°, Washington)	[illegible]
30°, New Orleans	[illegible]
0°, equator	[illegible]

The value of the English horse-power may also be given in metric units for various latitudes and altitudes, as follows:

TABLE 4

Value of the English and American Horsepower (746 Watts) in Local Kilogram-Meters per Second at Various Latitudes and Altitudes

Altitude	Latitude: 0° (equator)	30°	45°	60°	90° (pole)
Sea level	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] meters (=[illegible] feet approximately)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] meters (=[illegible] feet approximately)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

By interpolation one can take out of these tables the proper value of the horse-power in gravitation measure (either foot-pounds or kilogramme-meters per second) for any latitude and altitude.

EQUIVALENTS OF THE CONTINENTAL HORSE-POWER.

The continental horse-power is generally given either as 75 kilogramme-meters per second or as 736 watts. These two equivalents are independent definitions and are likely to cause confusion *unless* one of them is assigned to some definite place on the earth's surface. As pointed out in the preceding sections of this circular, the unit, to be definite, should represent the same rate of work at all places. The continental horse-power, then, should be taken as 736 watts, which is equivalent to 75 local kilogramme-meters per second at latitude 52 degrees 30 minutes, or Berlin. The number of kilogramme-meters per second expressing this amount of power will be smaller than 75 at more northern latitudes and larger at lower latitudes. The values at various latitudes at sea level are given in Table 5:

TABLE 5

Continental Horsepower (736 Watts) in Local Kilogram-Meters per Second

Altitude	Latitude: 0° (equator)	30°	45°	60°	90° (pole)
Sea level	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] meters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] meters	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[13] As explained in Sec. II, the standard foot-pound is that corresponding to g=980.665.

[14] The values given in these tables supersede those given in the first edition of this circular, which were calculated from a slightly different value of g. The equivalent used in this circular for the horse-power also supersedes that used in editions of this Bureau's "Tables of Equivalents" before 1912.

CONCLUSIONS.

It is considered desirable that the watt and kilowatt be used as the units of power, whenever possible, for all kinds of scientific, engineering, and other work. It is not unlikely that the unit of horse-power will ultimately go out of use. In the meantime, however, it is desirable that its definition be uniform. This circular has been written to point out that if the horse-power is to represent *the same amount of power at different places* its relation to the watt must be a constant number, and the number of local foot-pounds or kilogramme-meters per second which it represents must vary from place to place. Table 2 and others of this circular show clearly this variation with locality.

It might be feared that some confusion could arise because of the independent definitions of the mechanical watt and the "international" electrical watt. The watt and kilowatt are defined primarily in purely mechanical terms, and not electrically at all. That they have been used mainly in electro-technical work is merely accidental and is due to the fact that they are metric units and so fit in naturally with the metric units in which all electrical quantities are universally expressed. Any kind of power may properly be measured in kilowatts. For example, in the case of the hydraulic power furnished by a flowing stream, the power is given in kilowatts by multiplying 0.163 into the product of the head in meters by the flow in cubic meters per minute; the power is likewise given in kilowatts by multiplying 0.000188 into the product of the head in feet by the flow in gallons per minute. The watt is defined directly in terms of the fundamental units of mass, length, and time, in the "meter-kilogramme-second" system, thus: "The watt is the power developed by the action, with a velocity of 1 meter per second, of a force capable of giving to a mass of 1 kilogramme in one second a velocity of 1 meter per second." The "international watt," however, is defined in terms of concrete electrical standards, which electrical standards represent practically, as nearly as the limitations of experiment allow, the absolute electrical quantities in terms of their theoretical relations to length, mass, and time. The international watt thus defined is the closest concrete realization of the theoretical absolute or mechanical watt which we have. We can not at the present time say whether the international watt is greater or less than the absolute or mechanical watt, but the difference is probably not greater than a few parts in 10,000. Consequently, there is in reality no confusion between the mechanical watt and the international electrical watt.

It is recommended that engineering societies and other interests concerned recognize the value of the "English and American horse-power" as 746 watts (or 550 foot-pounds per second at 50 degrees latitude and sea level, approximately the latitude of London), employing Table 2 to obtain the value in foot-pounds per second at other places. It is likewise recommended that the value of the "continental horse-power" be taken uniformly as 736 watts (or 75 kilogramme-meters per second at latitude 52 degrees 30 minutes, the latitude of Berlin), and that the value in kilogramme-meters per second at other places be obtained from such a table as Table 5 of this circular.

It is probably not generally known that these values were adopted by a committee of the British Association for the Advancement of Science in 1873. This was a committee which recommended the cgs system, and on it were Sir W. Thomson, Carey Foster, Clerk Maxwell, J. D. Everett, and others (B. A. Report 1873, p. 222). The committee in its report said: "One horse-power is about three-fourths of an erg-ten per second. More nearly, it is 7.46 erg-nines per second, and one force-de-cheval is 7.36 erg-nines per second." (One erg-nine = 100 watts).

The Standards Committee of the American Institute of Electrical Engineers adopted, on May 16th, 1911, the following rule, which was inserted in the Standardization Rules of the Institute:

"In view of the fact that a horse-power defined as 550 foot-pounds per second represents a power which varies slightly with the latitude and altitude (from 743.3 to 747.6 watts), and also in view of the fact that different authorities differ as to the precise value of the horse-power in watts, the standards committee has adopted 746 watts as the value of the horse-power. The number of foot-pounds per second to be taken as 1 horse-power is, therefore, such a value at any given place as is equivalent to 746 watts; the number varies from 552 to 549 foot-pounds per second, being 550 at 50 degrees latitude (London), and 550.5 at Washington. The Standards Committee, however, recommends that the kilowatt instead of the horse-power be used generally as the unit of power."

The same value, 746 watts, is used by the Bureau of Standards as the exact equivalent of the English and American horse-power. The Bureau recommends the use, whenever possible, of the kilowatt instead of the horse-power.

The Rural School and the Hookworm Disease*

The Greatest Medium for the Spread of the Infection and the Most Important Protective Agency

In the development of education in the United States and particularly in the Southern States where the preponderance of rural population has retarded community control of sanitation realization of the health basis of education has been slow. Education in the south has advanced rapidly since the Civil War and more recently the rural schools have had their share in progress. Yet in this development the emphasis has persistently been on the school and the teacher rather than on the children to be educated. Only recently have educators turned their attention to the physical condition of the average school child and in the south they have done so largely because of the discovery of the enormously important part played by hookworm and allied diseases in educational progress or lack of progress. Hookworm disease is in a sense a special problem but it is a special problem of such magnitude affecting so large a section of our country as to be a problem of grave national concern.

Hookworm disease is one of the most prevalent most insidiously harmful and most completely preventable diseases known to man. It causes human suffering and economic waste altogether out of proportion to its apparent death rate. Many ills that have been attributed to mental and moral weakness of whole bodies of people are now definitely known to be due to this infection and curable with its cure. Its eradication is one of the most important and pressing problems before the people of the southern half of the United States and of other semitropical and tropical lands. Moreover the progress which has been made in recent years completely demonstrates at once the vast benefit both in terms of human happiness and industrial efficiency attendant on the stamping out of the disease and also the complete adequacy in stamping it out of perfectly simple precautions prescribed by the most primary rules of health and even of common decency. There is probably no other disease which is so well understood in every detail and which can be so satisfactorily explained to a layman. Nor is there any other widely prevalent disease against which the lay community can so readily and surely protect itself by simple precautions. Its conquest virtually resolves itself into a problem of popular education against soil pollution.

An Arkansas dispensary

Microscopist on field work in Georgia

In combating hookworm disease it has been found that the rural school is the greatest medium for the spread of the infection and the most important protective agency against it. In some schools investigated the infection has been found to be 100 per cent—the teacher and every pupil a victim of the disease. Records of the survey show an average infection among rural children of school age for whole counties running as high as 70 to 90 per cent. The general average for all the children examined to date is 40 per cent of infection.

It is seldom realised to what extent the school in rural districts aids in spreading the infection. Suppose we take a certain school district in which by chance no infection exists. The son and daughter of Mr Smith visit Mr Jones who lives in a district where there is much hookworm disease. While there fruits or strawberries are picked off the ground by the Smiths and eaten and perhaps in going barefooted ground itch the beginning of skin infection is contracted. The visit over the Smiths return home. Having no sanitary privy on their premises the soil around their home is soon polluted so that one by one the whole family becomes infected in varying degrees of severity. Fall comes and the neighborhood school opens. The Smith children may by this time be a little pale and puny from the disease but they start to school.

The school may be in a progressive community the house may be painted and furnished with patent desks and perhaps it has secured a creditable library. Good heaters have been provided the light comes from the rear and over the left shoulders of the pupils perhaps there is a driven well to supply water but there will be no bubbling drinking fountain. Worst of all no privy has been provided. The pupils not having a privy at home do not think of having one at school especially since the woods and undergrowth are near the school house. The Smith children do not know they are infected they use the common hiding grounds with the other children. Soon the whole school grounds are so heavily polluted that on damp days every pupil who goes around barefooted will contract ground itch and moreover those who play ball marbles mumble-the-peg etc get their hands infected. Facilities for washing the hands are not available so at lunch time they handle their food with soiled hands which are likely to be contaminated.

In this way the pupils at school become infected with the school as an exchange. In a comparatively short time the premises around the homes of all the school children are polluted and we have the change which anemia produces coming over the community. Progress of the children in school is retarded the daily attendance is poor the health of the community is below normal the crops are not so well cultivated there is a general backward tendency. The houses are not so well provided for or kept the whole community is sick and doesn't know it the economic loss is tremendous.

It is through the rural school whence the infection has come that the remedy must also come. The measures necessary for permanent control of hookworm disease are health supervision health instruction and perfect sanitation. The rural school can aid in health supervision it can supplement and drive home health instruction and above all it can teach good health and clean living by being itself a model of sanitation for the community.

Hookworm disease like typhoid fever is due to careless disposal of human excreta. Once schools and dwellings in country districts are provided with sanitary privies of one type or another there will be little danger from hookworm.

Infection by intestinal parasites is by no means confined to the south. It is world wide in its distribution. It is most prevalent in the tropical and semi tropical countries where it is a problem of great magnitude. Of the total population of the globe—about 1 600 000 000 people in round numbers—about 940 000,000 live in countries where hookworm disease is prevalent. In the microscopic examinations of the stools of persons six types of intestinal parasites have been found in sufficient frequency to render each one worthy of consideration, but the campaign in the south has been directed primarily against the hookworm because it is the most important, and by far the most prevalent of the group.

Hookworm disease is not new. It is only newly understood. The symptoms of the disease were described in the records of the Egyptian Empire, but their cause was not known. The hookworm itself was discovered in 1838 by Dr Angelo Dubini, an Italian, who while making an autopsy found the small white worm with its head buried in the membrane of the small intestine, but that this worm had anything to do with anemia was not suggested. When, however, in 1877, Grassi another Italian physician identified the eggs of this worm in the feces of anemic patients, it was suspected that the parasite was the cause of the disease. About the same time Dr Colomiatti studying an obscure disease which had caused the death of many workmen on the St. Gothard Tunnel, discovered in the intestine of one of the tunnel victims more than 1,800 hookworms.

The parasite known as the Old World hookworm and named *Ankylostoma duodenale* was carefully studied its responsibility for certain types of anemia in southern Europe demonstrated, and successful treatment for the disease developed. The prevalence of hookworm disease in the New World was not, however, recognized till much later. On November 24th, 1899 Maj Bailey K Ashford of the United States Army Medical Corps, while treating anemia supposedly due to starvation caused by the hurricane in Porto Rico identified the hookworm as the real cause of the widespread disease. He however supposed the parasite found by him to be the Old World type. In 1902 Dr C W Stiles, of the United States Public Health Service, having found the same disease in the southern states identified its cause as a different species of worm now known as the New World type or *Necator Americanus*. It was then discovered that the worm found in Porto Rico was of this species. Subsequent discovery of this same worm as the cause of anemia among the victims of the African low lands suggests that the so-called New World type was brought to Porto Rico and the southern states by the slave trade. It also prevails in India, and has been spread in Jamaica, Trinidad and British Guiana by the Hindu coolies brought there as laborers.

In the United States the disease is found throughout the states south of the Potomac and Ohio Rivers in Arkansas Missouri Oklahoma, and Texas and also in California. Its prevalence and severity vary widely within a state and even in a county in some localities less than 1 per cent of the people being infected, and in others more than 90 per cent. Generally speaking the heaviest infection is found on the light sandy soil of the coastal plains the lightest infection on the stiff, clay soil of the Piedmont region, and an intermediate infection among the foothills and mountains. It is peculiarly a disease of the agricultural districts, which goes far to explain the long puzzling lack of physical and intellectual vigor to be noted among large classes of people in what ought to be one of the healthiest and most prosperous sections of the country.

The treatment of hookworm disease is a simple matter. Epsom salts and thymol are the drugs used. The object desired is to clean the mucous and food particles from the intestinal tract, so that the worms will be exposed to the action of the thymol. This is accomplished by the administration at night of a dose of Epsom salts.

The next morning at 6 A. M one-half the dose of thymol in capsules is given, at 8 A. M the other half is given, and at 10 A. M a second dose of epsom salts is given. Having cleaned the mucous from around the worms, the thymol acts directly on them as a poison.

Alcohol and oils are solvents for thymol, and it is exceedingly dangerous for either of them to be taken by the patient. Gravy, butter, milk, etc., must not be taken on days when thymol is given. Patent medicines often contain alcohol, and must be forbidden. The plan followed has been to forbid any food or drink except water, on the morning when the thymol is taken.

Male fern, beta-naphthol, and other chemicals have been used in treating hookworm disease, but it is generally agreed that thymol is [illegible] the purpose.

* Extracts from Bulletin No 20 1914 issued by the U S Bureau of Education.

In the fall of 1909 it was announced that Mr. John D. Rockefeller had given a million dollars to be used in an effort to control hookworm disease. In January 1910, a commission composed of educators, doctors and business men of national reputation was formed and offices were opened in Washington by the administrative secretary. The work of this commission, which is known as the Rockefeller Sanitary Commission, has involved three definite tasks (1) To determine the geographical distribution of the infection and to make a reliable estimate of the degree of infection for each infected area; (2) to cure present sufferers; and (3) to remove the source of infection by stopping soil pollution

The State was adopted as the unit of organization and of work. It was regarded as fundamental, in the interest both of economy and efficiency, that the work be done as far as possible through existing agencies. Each State had its own system of public health, its own system of organized medicine, its own organized public press, its own system of public schools. These four fundamentals and a host of other agencies were ready for use in educating the people. These institutions were rooted in the life and traditions of the people, to enlist these agencies in the accomplishment of the task was to insure the permanency of the work from the beginning. The eradication of this disease, moreover, was a work which no outside agency working independently could do for the people if it would, and one which no outside agency should do if it could. It was recognized that an outside agency can be helpful only in so far as it aids the States in organizing and bringing into activity their own forces. In this spirit the commission responded to invitations from State boards of health to co-operate in organizing the work in those States in which widespread infection had been demonstrated.

In the 11 States thus inviting co-operation a State director of sanitation was appointed by the joint action of the State public-health authorities and the Rockefeller Sanitary Commission. The State director is a State official, an officer of the State department of health clothed with all the powers and responsibilities belonging to such position. He is the organizing and directing head of the whole work for the eradication of hookworm disease in his State and is responsible for the efficiency of the service. His work is done under the supervision of the State department of health, he reports quarterly to the State department and the commission.

Under the direct supervision of each State director of sanitation is a force of field directors of sanitation. These field inspectors are nominated by the State director and confirmed by the joint action of the State department of health and the commission. These inspectors constitute an ambulant service and devote their whole time to work in the field. It is these field directors who determine the geographical distribution and degree of infection, who determine the sanitary conditions responsible for the presence and spread of the disease. They enlist the co-operation of the physicians in curing the sufferers, provide for the treatment of the indigent, inspect schools, instruct the teachers, enlist the press, and, by lectures, demonstrations, and personal conference, teach the people the importance of getting all infected persons cured and how to prevent the spread of the disease by putting a stop to soil pollution.

As a definite diagnosis of hookworm disease requires a microscopic examination of the patient's stool, each State has a force of trained microscopists whose whole time is given to the examination of specimens received. This microscopic force is stationed at the State laboratory and in the field, in the latter case working with the field director.

The most effective teaching, whether of physicians, of editors, of school officials and teachers, or of the people, is by demonstration. The chief agency in this demonstration teaching has been the county dispensary for the free examination and treatment of the people. For this dispensary the county board of supervisors makes a small appropriation. The work is done by the field staff of the State board of health. The dispensary in a county runs usually from 6 to 8 weeks.

To summarize briefly, the aim of the work has been

1. To demonstrate to the people in each of the 11 States where work has been undertaken that hookworm disease is a reality; that it is a serious handicap, and that it is curable and preventable.

2. To make an infection survey that will give a reliable estimate of the degree of infection for each county in the State.

3. To make a sanitary survey which shall show for each county in the State the conditions of soil pollution which are responsible for the presence and spread of the disease.

4. To conduct an intensive educational campaign in every county where the infection is present; to teach the people by means of the printed page, by lectures, by [illegible], by demonstration, the importance to the [illegible] of getting every person examined and the [illegible] how the examination is made; how the disease is treated, how the infection is spread, and how it can be prevented

5 To teach the practicing physicians of the State how to diagnose the disease and how to treat it to teach them the importance of making examination for intestinal parasites a regular part of routine examination of all patients

6 To get every medical school in the State to make provision for definite instruction in the diagnosis and treatment of intestinal parasites to be given to all students as a requirement for graduation

7 To enlist the press of the State in the work

8 To see that the teaching of the dangers of soil pollution and how to prevent soil pollution is made a regular part of the instruction given in the public schools

9 To make at least one complete community demonstration, to select a rural community where the infection is reasonably heavy to get every person examined get every infected person cured get soil pollution stopped then tell the people of the State the story of how this community has eradicated hookworm disease

10 And, if possible, to help lay the foundation of a county and community health service that will in the end take care of hookworm infection and all other preventable diseases

Recently measures have been taken where the dispensaries have done their work thoroughly to follow the next logical step in the direction of permanent control of health conditions In North Carolina the State board of health has secured for a number of counties and communities full-time health officers who in addition to fighting hookworm diseases will do other needed health work Instead of selecting a county and spending a short time there—the dispensary method—the board now has full-time men employed who can remain until every case of hookworm disease is treated and cured In addition to this sanitary arrangements are being instituted for every home in the community, with a view to preventing hookworm disease, typhoid fever and all other diseases due to soil pollution

Co-operation between the State departments of health and education has been one of the most hopeful signs of progress in the movement for community control of health conditions In no field has this co-operation been more practical or effective than in the work for the eradication of hookworm disease The school authorities have furthered in every way possible the efforts of the State health authorities in the various steps of survey, cure, and prevention

In some of the States notably Virginia, North Carolina Alabama and Kentucky the alliance has been particularly close The State health authorities have furnished bulletins on public health especially adapted to use in the schools and the State school authorities have distributed these bulletins of information to all the schools in the States

Alabama has a specially prepared teacher's bulletin for use in the schools of the State, with an introductory note by the State director of campaign against the hookworm disease in the State

Kentucky is another State where special bulletins on health subjects have been prepared by the State board of health at the express request of the State educational authorities

In Arkansas State Supt George B Cook reports that the State department of public instruction has been very closely identified with the work of the Rockefeller Sanitary Commission since the work was first taken up in that State and that his department is also co-operating to the fullest extent with the State board of health

Kansas, while not one of the States where hookworm disease is a problem offers a good example of State wide health teaching in country schools In the new course of study issued for use in all the rural schools of the State, special stress is laid upon sanitation and health-conserving agencies in general

In reporting on health teaching in Louisiana State Supt Harris mentions particularly the work of the State board of health in co-operation with the Rockefeller Sanitary Commission, emphasizing the fact that while engaged in the work of examining and treating school children and teachers "they give a great deal of instruction in other lines of health"

In Mississippi a valuable health work that means much for the hookworm crusade as well as for every other positive movement for good health is the work of the State school improvement associations By means of these associations, working through the State department of education, a special "clean-up and beautify day" has been observed by at least 2,000 schools and communities at the close of school in the spring and again at the opening in the fall On these days the country people join with the teacher to put their schools in sanitary condition and make them as attractive as possible

It is the general testimony of those who have investigated actual rural conditions that the rural school is ordinarily inferior in building and equipment to the average farm dwelling of the community it serves Certainly in respect to sanitary facilities it has been a disgrace to American civilization Recently, however, much has been done toward making the school house and grounds in the country what they should ever be—a real model for the community to follow In States where the rural movement is at its best particular attention is paid to the two fundamentals of water supply and sanitary privies

No problem is of more fundamental importance to rural life than that of disposing adequately of human excrement It has been repeatedly stated in this bulletin that hookworm disease would be impossible without soil pollution and soil pollution is directly due to the lack of sanitary privies Theoretically the remedy for soil pollution is simple and should be provided with enthusiasm everywhere in the country at every farmhouse and at every school Practically its application is very difficult Ingrained habits must be changed and to accomplish this requires that people be educated out of the present uncivilized custom to the point where they will gladly devote the necessary time and money for the construction and use of sanitary facilities for night-soil disposal in other words sanitary privies

Model Target Ranges in Belgium

A few years ago the Belgian military engineering corps undertook some interesting work in reinforced concrete construction at the time of laying out the new rifle ranges at Ostend. This locality is now covered by the present war operations in Belgium The firing grounds were intended to be a model establishment and a novel point was the extensive use of firing walls or backing for the targets built of reinforced concrete and ranging from 90 to 70 feet high Such a system had already been put in use in Switzerland and other places to a limited extent and owing to the valuable qualities of reinforced concrete for this class of work it was decided to go into the present construction on a much larger scale than had been heretofore seen Plans for the complete firing ground at Ostend called for four firing lines at 330 feet range four lines at 660 feet, five at 1 000 feet four at 1 330 feet three at 1 650 feet and two at 2 000 feet range this being as will be seen quite an extensive layout all these firing lines to be provided with electro-automatic targets of the Bremer type which give an automatic record of the firing points However only a part of this programme was carried out during the first part of the work to which our obtainable information has reference In the same way the shelter for the firing men is temporarily built of wood lined with canvas in order to deaden the sound The flooring of this shed construction is built on piles so as to raise it some 15 feet above the ground level The plans call for a total length of 770 feet for this part of the work Provision is also made for pistol firing as well as for combined firing by squads and other operations Taking the case of the 1 000 foot range as an example the firing walls placed opposite the stand and holding the targets are built as five separate walls with space between Such walls are of flat surface in front except for various niches to hold the targets as well as suitable protecting parts of which the details are not given The wall has about 7 inch thickness in itself but is greatly reinforced by webs in the shape of buttresses in the rear which start flush with the wall at the top and slant to the base so as to project no less than 10 feet or more at the ground level The walls vary in length and are either square or oblong shape the buttresses on each of the walls being spaced at reasonably close intervals for instance five of them per wall in some cases Metallic web reinforcing on the French Hennebique system is used here and the surfaces which lie above ground receive an outer coating of cement mortar The present walls are calculated to stand a much higher wind pressure than the heaviest tempests could produce and are thus very safe in this respect the broad base giving all the stability needed For the 1 000-foot firing line the heights of the walls range from 30 feet to 75 feet

Experience shows that reinforced concrete walls of this kind receive but little damage from the bullets but in the Ostend construction the walls themselves are protected by mattresses consisting of 1½ inch planking spaced at 8 inches in front of the surface of the wall then filling in the space with broken porphyry fragments of 1½ to 2 inches in size In France such planking and filling is used alone for making up a back wall for firing grounds and it is found that the shot will not penetrate it in any case so that the Ostend construction has an extra margin of safety Suitable precautions have also been taken to prevent glancing of the bullets from the targets or the walls. On the whole the present layout is a model one of its kind and shows another useful application of reinforced concrete It is not stated what has become of the firing grounds since the war operations about Ostend.

The Defense of Belgium by Inundation

Something of the History and Geography of the Flooded Region

By P Sallior

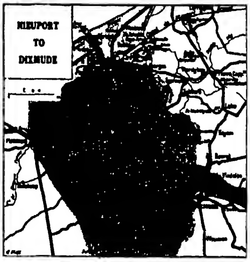
In all ages the regions bordering on the North Sea have made use of inundations as a means of defense After having worked for centuries to wrest land from the sea by artificial agencies Belgium and Holland claim the right of returning for the moment to the waters the territories which they have won from them During the defense of Antwerp it proved impossible for the district that could be submerged to yield the desired results During the battle of the Yser however the zone of Nieuport and Dixmude found inundation a valuable means of resistance While the war-ships of the Allies drew near the coast to bombard the Germans and batteries of artillery rained shells upon the district the lock gates were raised the dikes broken down at the right moment and the water flowed again over the land entering the trenches of the enemy and thus any farther progress of the Germans was rendered impossible

An interesting account of this heroic undertaking is given by a writer in *La Nature* who describes this entire section of Belgium as a charming region filled with sleepy old towns redolent of the past possessing belfries markets old houses and peaceful convents of Beguines having bridges across the canals accustomed to quiet and tranquillity It was customary for travelers to go to Nieuport to see the memorials of daring seamen and the surroundings of an old seaport to Dixmude to inspect the roodloft of the church and the town hall to Ypres to see the wonderful market-building and the belfry Along the coast there were sandy beaches at Nieuport Middelkerke Mariakerke Ostend and Blankenberghe where children were wont to play

One day continues our author the swarms of an adversary fell upon this region the cities of which are no longer more than names on the map or heaps of ruins The foe had two aims in view to drive back the left wing of the Allies in order to resume its unending turning movement and also to advance by way of Furnes to the capture of Dunkirk which once in its hands would become a base for naval operations against England Toward the middle of October this attack by the enemy was begun in the region between Nieuport and La Bassée and the operations were particularly violent at the outset along the coast The Yser River which has been turned into a canal makes a long bend between Nieuport and Dixmude and during several weeks its banks were the scene of a violent struggle The Belgians very quickly comprehended the aid which the water could give them There were fine locks at Nieuport that Baedeker had advised his compatriots to go see as masterpieces especially the locks of the canals of Bruges and Furnes as well as four others that are noted on the accompanying map Successive use was made of these locks and thus it was that the German attacks were progressively forced back from the lower courses of the river to the upper in proportion as the waters rose and encroached upon the land on the left bank of the canal Up to October 21st the most severe attacks of the foe were at Nieuport and Lombartsyde On October 22nd when the waters reached Schoorbakke the troops of the enemy forced a passage for themselves at Tervaete but were stopped three kilometers farther on at the railway line near Pervyse where one thousand dead Germans were found after a battle On November 11th however a success at last threw into their hands temporarily the ruins of Dixmude which had already been taken and retaken several times but even this advantage did not enable them to gain the left bank of the Yser By the end of November thanks to the aid of higher tides the inundations had extended over so large a region that the great German effort in which more than 120 000 men are said to have fallen had to be abandoned and the attacks reported after this were in a more southerly direction towards Ypres The water has been seen extending from Nieuport to the immediate vicinity of Ypres flowing in its course through Schoore Leke Dixmude Bixschoote and Boesinghe One result has been the capture of heavy artillery sunk in the miry ground near Ramscapelle where four large cannon and two mortars were gathered up out of the mud

The present war is by no means the first time that this district has served as a battlefield In 1489 Nieuport was besieged by the French In 1600 Maurice of Orange won a victory there over the Spanish and in 1658 the Battle of the Dunes was fought not far from Nieuport in the direction of Dunkirk when Turenne defeated Prince de Condé and the Spaniards during the course of a campaign not so dissimilar in its happenings to the events that have just taken place

At the period of this battle it should be recalled the French and the English were allied as at the present time The forces of the enemy held Gravelines Dunkirk Bergues and Furnes The entire region around Dunkirk had been inundated by them Notwithstanding this Turenne marched boldly from Cassel to Bergues and following from the latter place the only practicable dike he reached the dunes with the intention of besieging Dunkirk At this moment Condé who had collected at Ypres the Spanish garrisons advanced to meet him and was defeated June 14th 1658 Eleven days later Dunkirk capitulated This was followed by the capture of Bergues Furnes and Dixmude which was taken July 4th Gravelines surrendered on August 30th and on September 26th Turenne entered Ypres



Map of the inundated Yser region

In explaining the physical and hydraulic conditions of the region which permit this method of defense the writer says further

If a topographical map or what is better a map of the geological strata of this district is examined it will be seen that a line of dunes runs along the coast from Gravelines to Dunkirk Furnes and Nieuport These dunes are united into a monotonous plain only broken by the slight elevation near Bergues or Hondschoote of older alluvial formations and thick beds of a clay called Flanders clay (of the stratified formation called Ypresian) which varies from a thickness of 140 meters at Ostend to 80 meters at Dunkirk

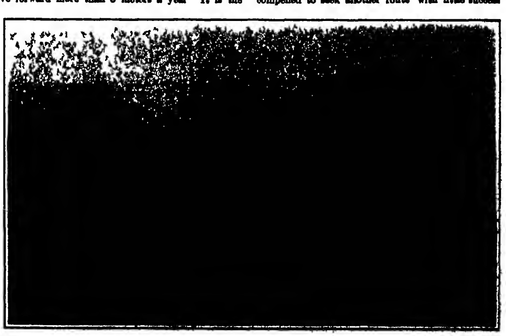
In traversing this country starting from the coast there first appears a low sandy shore a large expanse of which is exposed at each turn of the tide Then when a northwest wind blows the sand is pushed toward the coast dunes are formed and always owing to the same influence those dunes advance inland while the sea attacks them behind East of Dunkirk the dunes move forward more than 5 meters a year It is the region of the leaden-hued landscapes which the painter Cazin loved to use as a background for Palestinian scenes The strip along the coast formed by these dunes is only broken by the mouths of streams of small importance These river-mouths are habitually shut by lock-gates that are only opened at low tide when their discharge can take place

The plain back of the dunes is composed of a clay, whitish from the admixture of sea-shells at times a peaty subsoil is found below this clay A layer of peat, which is often a meter thick underlies this clay at about the meridian of Dunkirk Broken and recumbent trees are scattered irregularly through these strata. Innumerable canals and their subdivisions wind through this clayey plain which contains many stretches of verdant reclaimed land

The entire region has been wrested foot by foot from the sea and is like the Netherlands, of which it is a continuation a marvel of human ingenuity

The general level of the plain is in fact 0 60 meter below high water and in certain depressions called moeres it falls to 1 60 meter below high water In order to form the polders or tracts of reclaimed land it has been necessary to shut off the sea gradually by dikes crossed by drainage canals and to establish gates to regulate the flow of the water by preventing its discharge excepting at low tides Although this work of conquest was begun many centuries ago there still existed at the beginning of the 16th century a large number of salt lakes which have been drained off one after the other the moeres during the 17th century the salt-lakes of Lannes Robelin and Taaf during the 18th century

It is consequently very easy says the writer in summing up to understand the method of defense that has been employed In ordinary times the gates are closed when the sea rises If the procedure is reversed the rising tide penetrates the region by means of the entire complicated network of canals shown on the map and the closed gates will prevent it from flowing off while retaining also the fresh water If a person knows how to make use of the highest tides more than a meter in height over the level of mean tide can be gained By breaking the dikes at suitable points one or another section of the country can be inundated as the embankments of a railway or of a road forming a dam The ability to use the locks is a fine art but the low districts of Belgium have like the Dutch old experts who have been trained by long experience and who know all the tricks of the trade It is said that the combination by means of which the German trenches were submerged while the Belgian trenches were protected for a sufficient length of time is due to one of these men The map shows the extent of country liable to inundation, which includes almost the entire triangle of Dixmude Nieuport and Furnes To the east and south of Dixmude the sands and clays of the Ypresian period are on a little higher level which protects them from the invasion of the sea The Germans have tried in vain to stop the inundation or to cross over it by means of rafts They have been compelled to seek another route with little success



Scene in the flooded region of Belgium.

Deformation of the Earth by the Moon*

Methods of Solving the Problem and Its Difficulties

By Otto Klotz

In chapter VI of "The Tides" by Sir George Darwin he discusses the deflection of the vertical by the tide-generating force of the moon. In 1879 in conjunction with his brother Horace, he attempted to measure the microscopic movement of a pendulum under the influence of the lunar attraction. The difficulties encountered "led us to abandon our attempted measurement and to conclude that all endeavors in that direction were doomed to remain forever fruitless. I can but hope that a falsification of our forecast by M. Ehlert and by others may be confirmed." This is the concluding paragraph in that chapter, and the forecast as we know has been disproved first by the observation of Hecker, later by Orlov, Michelson and others.

If the earth were perfectly plastic then there would be no oceanic tides relative to the land, for both would be deformed equally and tide gages would record no rising or falling of the water. Otherwise, if the earth were perfectly rigid then we would have the greatest effect of oceanic tides by the lunar attraction. As the earth occupies a condition intermediate between perfect plasticity and perfect rigidity, the ocean tides are considerably modified thereby. Darwin gives the intensity of the maximum horizontal force due to the moon compared with gravity as 1 to 11 660 000. As is seen this is a very small quantity and the difficulty of observing or determining it is manifest.

We will attempt to give an elementary exposition of observing the effect of lunar attraction in the solid earth by means of the horizontal pendulum and evaluating the recorded results. In outline the horizontal pendulum is simply a bob supported at one end of a horizontal boom, the other end being movable at a steel point resting in an agate cup, while fine wires support the bob from a point on a vertical rod. Now this latter point is not quite vertically above the lower point, and therein lies the merit of the horizontal pendulum. If the axis of rotation were vertical then the pendulum would not oscillate when displaced from any position it might occupy. However as soon as this axis is inclined to the bob, the pendulum will oscillate when displaced from its zero position, and the period of its oscillation, that is the time required to make a to-and-fro movement, will be dependent upon this inclination of the axis. The period is a function of the angle of inclination to the vertical. This angle is a matter of instrumental adjustment, so that we can give the pendulum a definite period of oscillation to suit our purpose of investigation. If for instance its period is 10 seconds for a single vibration, this would be equivalent to an ordinary pendulum hanging vertically as in a clock of approximately 100 meters in length, or say 330 feet. Expressed in this manner one sees what a very small force indeed would be required to deflect the latter pendulum from its vertical position. Now this deflection we could accomplish too by tilting the support on which the pendulum hangs, that is if the surface of the earth suffered a tilting or inclination to the horizontal the vertical pendulum would move through the same angular measure, and the longer the pendulum the more easily could we measure the linear displacement. With the above equivalent 100-meter pendulum we would have a maximum deflection of the 11,660 000th part, or a little less than one hundredth of a millimeter. Knowing the mass and distance of the moon as well as the intensity of gravity it is a simple mathematical problem to calculate the deflection of the vertical at any time for a rigid earth.

The physical tides of the earth follow the apparent motion of the moon, and hence the deflection of the pendulum has a to-and-fro movement under the lunar attraction twice a day and with far greater regularity than obtains with the ocean tides, which are impeded in their onward course by the configuration of the earth's surface, i. e., by the continents.

We are speaking only of the lunar attraction while there is, too, one due to the sun, but as the former preponderates, in the ratio of about 7 to 3 we refer only to the former, although the latter is considered, and enters into any observation as well as into the final computation and reduction.

If then the theoretical deflection, on the supposition of an unyielding earth can be computed and the actual deflection of the vertical under lunar attraction can be observed, it necessarily follows that we have the data for determining the "give," the yielding, the rigidity of the earth,—a value of the utmost significance in geophysics.

It may be proper to state here, although it will be referred to later, that observations to measure the deflection are subject to certain indirect effects, among which may be mentioned the daily heating of the earth by the sun, whereby a bulging of the earth's surface following the sun is caused and a consequent tilting or deflection of the pendulum. This may amount to many times—as much as 50 times the gravitational effect of the sun. Again if the pendulum is mounted say within a hundred miles or even more of the sea-coast the ocean tides exercise a dual influence. In the first place high tides loading the sea-shore bend it, and the degree is dependent upon the elasticity of the rock subjected to the pressure. This effect making plausible assumptions admits of approximate estimate. Then again the mass of water brought in by high tide exerts a gravitational effect on our pendulum just as the moon does and helps to mask the true lunar effect. The bending of the earth's crust however under the superimposed water mass is for near-coast stations of far greater effect than the gravitational one of the same mass. The two latter would synchronize with each other but not with the solar heating effect. The further we advance with the problem of measuring the deflection of the vertical by lunar attraction the more complicated and difficult of realization it becomes. Low tide due to the withdrawal of water has of course the opposite effect of high tide.

From observations it has been found that the earth has about the rigidity of steel, a conclusion arrived at by Kelvin years ago and by quite another line of attack, and furthermore that the terms dependent upon the sun are largely influenced by meteorological conditions, among which the daily heating of the earth has already been referred to. The change of declination must also be considered.

It was taken for granted that the magnitude of the deformation of the earth would show no selective azimuth, but observations showed this not to be the case. Taking the mean of the observations at Potsdam, Dorpat, Freiburg and Durlach we obtain 0.47 for the meridian and 0.70 for the prime-vertical value of the theoretical value they should respectively have, which means that the earth is more comprehensible in a north-south than in an east west direction. This anomaly was puzzling. Sir George Darwin suggested that the greater rigidity of the earth in the east-west direction was due to the rotation. Prof. Love however from mathematical considerations could not assign this as a reason. He however pointed out the possibility, as the difference was more marked at Potsdam, which is nearer to the ocean than in Dorpat, that the ocean tides might be the disturbing factor and in two ways. In the first place there must be a bending of the earth's crust under the tidal weight, and in the next place the tidal mass exercises its gravitational influence just as the moon and sun do. Acting on this suggestion the International Seismological Association at Manchester in 1911 decided to have four "deformation" stations established, one in central Siberia, one in central South Africa, one in central North America—these three being far removed from the ocean—and one in Paris, where the above effects, if they exist, would be aggravated or increased. Canada undertook to establish the one for America, and Winnipeg was first selected, but it was finally decided that more satisfactory results would be obtained at Ottawa at the Dominion Observatory under constant technical supervision. Recently a concrete vault 9 by 21 feet has been built adjoining the Observatory, the floor of the vault being 24 feet below the surface, and the pendulums will shortly be installed.

Since the observations have been made in Europe Prof. Michelson has carried out a splendid series of observations and by quite a new method, using two long (500 feet) pipes, 6 inches in diameter, the one laid in the meridian, the other in the east-west line and both underground 6 feet. They are partially filled with water and the change of level under lunar and solar attractions is measured by means of a microscope. A detailed account of the apparatus and results will be found in the March number of the *Astrophysical Journal* for the present year. We shall give his final results. He finds—

Amplitude Ratio		Phase Acceleration	
N-S	0.523	−	0.007 hour
E-W	0.710	+	0.059 hour

We see that the amplitude ratio is in pretty good accordance with the mean European results of 0.47 and 0.70, and from the position of Michelson's station—Williams Bay, Wisconsin, near the Yerkes Observatory, very far away from any oceanic tidal influences the cause of the anomaly of this difference in amplitude ratio, will very likely have to be sought elsewhere—although Schweydar (1912) agrees with Love in attributing the difference as found at the European stations to the effect of ocean tides. The phase acceleration as found by Michelson is very satisfactory, being very small as one would expect. "It is as he says so small as to leave some doubt as to whether or not it is real."

We have shown in the preceding the problem to be attacked and the method of attacking it. Attention has been drawn to the very small quantities involved, that is the quantities to be measured, and of the numerous factors that enter into it, the continuous change of the moon's position in declination and distance, with the consequent change in its tide-disturbing effect. The same applies though in a less degree to the sun. To complicate our record still more we have meteorological effects impressed on the records, such as the heating effect by the sun. Yet from all the tangle the physical tides of the earth show up clearly and unmistakably. At a maximum the surface of the earth rises and falls about a foot twice a day due to lunar and solar attraction. We are sitting on a long teeter (6 000 miles long) with a period of a little over 12 hours) unconsciously teetering. It doesn't seem to mean much, yet in it is bound up the constitution of our earth and of all objects in the universe none concerns man more than the earth. The earth is solid, very solid, somewhat like steel. There is no liquid molten interior as we were once led to believe.

We trust that in another year the Dominion Observatory will be able to add its share to this very interesting investigation of the deformation of the earth by the moon and sun, and the determination therefrom of the rigidity of the earth, a desirable quantity in geophysics.

*The Journal of the Royal Astronomical Society of Canada.

Comparison of the Silver and Iodine Voltameter

An important investigation of silver and iodine voltameters was recently undertaken by G. W. Vinal, assistant physicist of the Bureau of Standards, in co-operation with S. J. Bates, research associate in physical chemistry of the University of Illinois, the results of which have been published in the scientific papers of the Bureau of Standards No. 218. A brief summary follows.

Of the many electrochemical reactions which may theoretically be employed to determine the faraday, i. e. the quantity of electricity associated with a chemical equivalent in any electrochemical change, that of the deposition of silver from a solution of silver nitrate is the only one that has been extensively investigated. The values which have been accepted for the faraday from time to time have almost entirely been based upon results with the silver voltameter. This naturally resulted from the fact that the international ampere is defined in terms of the silver deposited under more or less rigorously fixed conditions, and hence this instrument has been the subject of many thorough investigations both by the national standardizing laboratories and by private individuals. As a result of these investigations it has been possible for the past few years so to define the conditions to be used in connection with the silver voltameter that a reproducibility of 1 or 2 parts in 100 000 may be obtained. Until recently no other voltameter had attained anything approaching such a degree of precision.

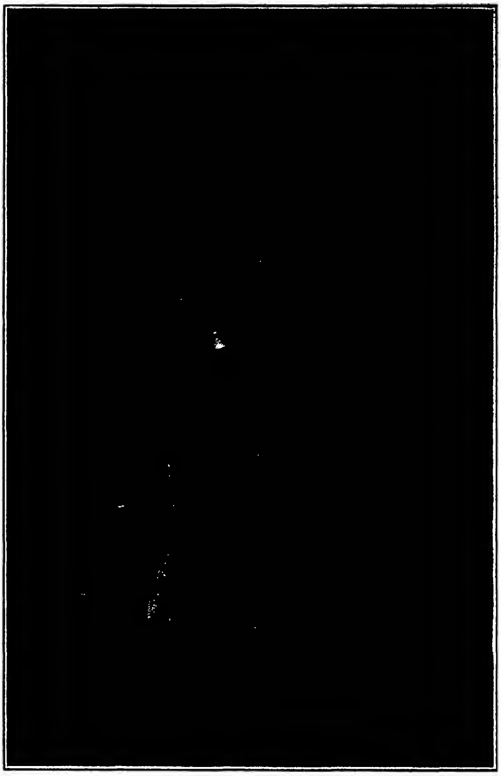
A little over a year ago, however, Washburn and Bates[1] published the results of a study of an iodine voltameter which they had devised and which was found to have a reproducibility of the same order as that of the silver voltameter. The apparently complete reversibility and purity of the electrochemical reaction in the iodine voltameter coupled with the fact that no solid deposit is obtained made it a particularly valuable reaction to employ for determining the faraday and warranted very exact electrical measurements.

We have made a careful comparison of the silver and iodine voltameters, using them in series so that the deposits of silver and iodine should be strictly comparable. The best procedure learned from previous investigations has been followed in each case. Our results are as follows:

1	Ratio of silver to iodine	0.850017
2	Electrochemical equivalent of iodine	1.31502
3	Value of the faraday (I = 126.92)	96 515
4	Value of the faraday (Ag = 107.88)	96 494
5	Value recommended for general use	96 500

Nos. 2, 3 and 4 are calculated on the basis of the international ampere using 1.11800 milligramme per coulomb as the electrochemical equivalent of silver.

[1] J. Am. Chem. Soc. 34, pp. 1341, 1515, 1912.



Removing a bit of steel from his eye.

Removing Particles of Metal from Wounds

Pittsburgh's great industrial plants are furnishing practically all the barbed wire used by the belligerent countries in the European war and thousands of tons of material for the making of ammunition are being shipped from Pittsburgh to Europe

This city's commercial participation in the war is greater perhaps than any other city enjoys—in so far as manufactures are concerned. But besides furnishing so much that is intended to destroy human life Pittsburgh is sending in large numbers one mechanical agent of mercy to the battlefields of France Austria and Belgium It is the powerful magnet that is taking the place of the surgeons painful and perilous probe—a machine that will prevent untold agony

The removal of pieces of shrapnel, steel jacketed bullets and other metal substances by the use of powerful electromagnets in hospitals in the European war zone has been acclaimed by many as the very latest application of science to surgery But this has been in practice in some of the Pittsburgh industrial plants for more than a year the first machine having been constructed and installed at the East Pittsburgh works of the Westinghouse Electric and Manufacturing Company As part of the relief department it has proved the most useful device ever adopted and the big magnet is here used for removing metal embedded in the flesh or in the ball of the eye.

The magnet is mounted on a box containing a resistor which is used to regulate the amount of current flow in the coils It requires 4 000 watts for its operation or enough power to supply one hundred 32 candle-power Mazda lamps. It is designed for operation on 70 volts As the circuit from which it draws current is used for testing purposes in the Westinghouse works and ranges from 70 to 120 volts a resistor is necessary

Not infrequently workingmen get bits of metal in their eyes or hands Before the installation of this magnet it was necessary to use a probe to remove these foreign substances a method which was uncertain and often extremely painful This magnet makes the operation very simple and painless. The part of the body in which the metal chip is embedded is placed near the pole tip of the magnet, the switch closed, and the magnet does the rest. The pole is removable, a number of different shapes being supplied for various classes of work. Bits of flying metal often penetrate the eyes of workmen When they strike with sufficient force to be embedded it is a difficult thing to extract them unless the magnet is used. The protecting coating of the eye must be cut, and there is always danger that, instead of removing the particle it may be pushed further into the eye

In the steel mills workers frequently have their hands punctured by minute pieces of flying metal which become embedded under the callous skin. When these bits are allowed to remain, in most cases the wound becomes infected. Sometimes blood poisoning results. The use of the powerful magnet insures the removal of all traces of metal from [illegible] and all [illegible].

Dr C. A. Lauffer, medical director at the Westinghouse plant, has compiled some valuable data on the results accomplished by the magnet. Not long ago a workman at East Pittsburgh attempted to drill one of his own teeth. The drill broke off about a half inch from the end and remained stuck in the cavity It looked as though the only way to remove the drill would be to pull the tooth. A special extension to the magnet pole was contrived and fitted to the machine. As soon as the current was switched on the drill was drawn out.

Astronomical and Mathematical Research*

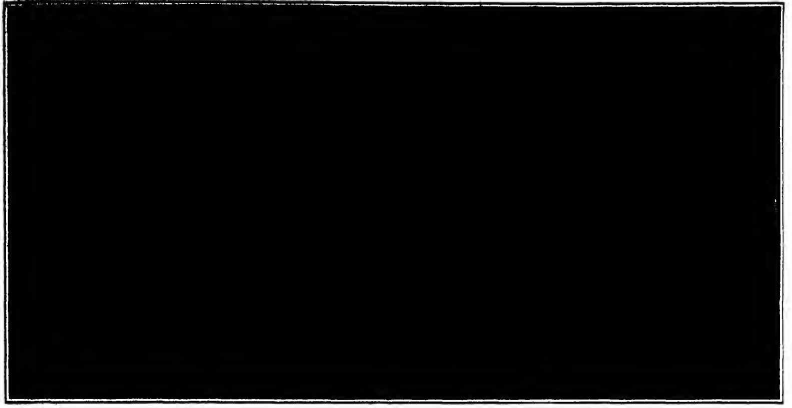
The astronomer in common with the physicist, the chemist and others greatly needs the help that the mathematician can give On the other hand, I believe that the mathematician has something to learn from the astronomer with regard to the point of view from which he pursues his researches

This difference in viewpoint is nothing more than a recurrence of the struggle that occurs in every kind of human activity between the essentials of a subject and the technique of that subject It is a remarkable fact that the outcome of this struggle is not always in favor of the former but that mere technique is sometimes able to gain permanent mastery and to submerge completely the objects for which it was created The best illustration of this is to be found in the painter's art We know that there was a time when painting was regarded as a mode of expression through which lessons might be taught and learned, or through which at least the world might be amused But for many a long day painters have refused to take this view of their art They hold in frank contempt a picture that tells a story and their standards of what constitutes a great picture are unintelligible to any one who is not himself a painter

Astronomy and mathematics have their technique and are having their struggle with it A century ago Gauss a great mathematician and a great astronomer speaking for his times as much as for himself announced as his motto Pauca sed matura and adopted as his crest a tree laden with fruit few in number but remarkable for their perfection Such sentiments as these and the feeling that lay behind them have undoubtedly done more to hinder the progress of science than to advance it If there is any question as to what Gauss meant we have only to turn to his biography to find the answer He did not care to touch in print any subject that he felt he could not exhaust merely to contribute to it seemed to him like plucking unripe fruit Thus his published work extensive though it is represents only a part and it may be only a small part of the unremitting labor of his wonderfully fertile brain We know for example that Gauss had developed the principles of the method of least-squares while he was still in his teens but it was not until fourteen years later that he ventured into print on this subject He would doubtless have wished to delay even longer had not Legendre in the meantime unearthed and published the same principles We can make a good guess at the reasons for Gauss's delay The method of least-squares is founded upon an assumption which can be put in various forms but which always remains an assumption Gauss would doubtless have wished to prove this assumption from fundamental principles or at least to have given it a more axiomatic dress but this neither he nor any one that has come after him has succeeded in doing An even better illustration of the former attitude of men of science in the matter of their obligations to science is afforded by Gauss's part in the history of non Euclidean geometry In a letter to a friend he states that he had occupied himself extensively with Euclid's axiom concerning parallels and goes on to outline very briefly some of the results he had obtained. This letter contains all that is known of these researches A few years after it was written Lobatschewski published the little book in which he proves that the parallel axiom is no axiom at all, but a pure assumption and shows that another kind of geometry is imaginable in which the opposite assumption is made In view of this work, it would have been necessary for Gauss to revise what he had already done before publishing it He preferred however, to suppress it altogether and when after his death his scientific effects were overhauled, no trace of this subject was found among his papers

It will be understood that it is not Gauss that I am presuming to criticise, but rather the times in which he lived. That was an age when it was taken for granted that a man should think of his scientific reputation as coming first, and when the form in which he gave his researches to the world was considered as important as their content In more recent times the man of science has taken a new view of his calling and of his [illegible] It is largely because of this new policy that progress has been so rapid in [illegible] directions.

*Address by [illegible] [illegible] of the American [illegible] [illegible] American Association [illegible] of Science.



Entrance to the vault, showing the 3 foot thick 50 ton door open and closed with joint ground to an air tight fit

The Strongest Vault in the World

Its Massive Construction and Unusual Method of Protection

THE security vault recently installed in the new banking building of Messrs. J P Morgan & Co has the unique distinction of being the strongest in the world. It is 28 feet wide by 37 feet deep by 33 feet high outside and is divided into three stories The walls are 2½ feet thick made up of a harveyized nickel steel armor plate lining surrounded with rock concrete reinforced with double and treble sections of 125-pound nickel steel rails, interlocked at all corners and bound with multiple angle frames and tie rods The outside is finished with a steel panelled cladding

The main entrance is guarded by a round door which is made without stepping or rebates, and is ground into the frame for its entire thickness of 36 inches. This door is of composite construction the inner half being of nickel steel armor and the outer of cast steel with concrete, jail rods and anti-oxyacetylene cutter burner proof sections between This door with its boltwork and hinges weighs 50 tons and is so well balanced that it can be swung with one hand.

An emergency door of corresponding thickness and construction but of lesser size obviates the possibility of lockout and furnishes means for ventilation the air being changed every two and one half minutes

The three floors of the interior are equipped with security closets and safes, filing fixtures trucks etc The floors are finished with cork tile Stairways afford communication between floors and an elevator is provided for trucks and packages A level entrance is afforded by lowering platforms

The vault is provided with two systems of electric lighting a high tension which is regularly used and a low tension which is brought automatically into service if the high tension fails.

A complete system of calls alarms and telephones is also installed, in addition to a telephone permanently connected to Central for use if a person is locked in the vault The night lights also run continuously

Time locks are applied directly to each door which is solid and has no spindle holes the combination locks and bolt throwing mechanism being applied to the jamb

All of the combination and time locks and bolt throwing mechanism upon the inside of the vault are covered with heavy steel plates which obviates an almost universally weak condition where the putting of a small hole through the vault walls provides direct access to the locking connections

A protected and electrically lighted dial with revolving pointers has been substituted for the standard combination lock dials this affording greater convenience, and insuring the operation of the combination against observation from anyone except the operator

Electric protection is applied over the entire vault and is connected with Central Office service The vault is arranged for observation by means of patrol passages and mirrors around the four sides underneath the bottom and across the top

The work is fire proof water proof burglar proof and mob-proof and as a whole represents the very last word in high class vault construction

Refractory Materials and the War*

THE successful manner in which the Germans have developed the manufacture of various heat resisting materials has been clearly demonstrated since the advent of the war and as time goes on the absence of supplies becomes more and more trying in those industries where heat-resisting materials are required The manufacture of chemical porcelain for instance, is almost unknown in Great Britain, and we have to depend for supplies of this ware on goods which are obtained more or less surreptitiously through neutral countries such as Holland and Scandinavia. The supplies stocked by dealers have never been very large, and these were rapidly depleted. This encouraged a number of British potters to make some simple attempts at the manufacture of refractory porcelain, but most of them soon abandoned it, for though they could make ware which would withstand acid they could not produce a porcelain with the insensitiveness to sudden changes in temperature which is so characteristic of the Saxon ware. Other experiments are being continued, and it is hoped that before long this ware, which is so important to chemists, will be successfully manufactured in this country at prices not markedly higher than have been paid for the imported material. Meanwhile, the use of fused silica ware or "vitreosil" is increasing, as it will meet all the requirements, but is more costly than porcelain.

The importation of bricks for building coke ovens and other furnaces from Belgium and other parts of the Continent has necessarily ceased during the war Firebricks of equal refractoriness can be purchased in this country but they do not satisfy the tests which the Continental builders of coke ovens consider to be essential British firebrick manufacturers are making extensive efforts to overcome these objections and are gradually increasing their ability to make firebricks to fit any reasonable specification They have much to learn however though they have made much more rapid progress since the war began. Firebricks for furnaces and similar purposes where the specifications are less stringent can be made successfully in this country though the prices of firebricks in extra European countries before the war were largely in favor of those made in Germany This was due to the much larger works organized on an entirely different basis and working on a system of "dumping" which does not appeal to British manufacturers It is a curious fact that with inferior materials to those commonly used in Great Britain, the Germans have turned out better firebricks and have been able to guarantee results to an extent which British firms have found impracticable. With competition less severe in some respects British manufacturers are now turning their attention to improving the qualities of their goods, as in the past they have concentrated their minds on the production of cheap bricks. With adequate technical assistance of a kind not generally available they will be able to make great improvements in quality and should in time be able to produce better bricks than any now on the market. Retorts for the manufacture of coal gas cannot now be imported from Germany so that gas engineers are compelled to use the home-made products There is much divergence of opinion as to the relative values of British and German retorts and its has not been unusual to find German engineers importing British retorts while some British engineers have preferred to purchase German ones Here again British manufacturers are trying to meet the demands as far as they are able to do so.

The chief difference between British and German refractory materials may be traced to the difference in the ownership and management of the firms In this country refractory materials are chiefly made by men who have worked themselves up from a small beginning—or the descendants of such men—their chief characteristics being that of a workman whose knowledge and experience have been gained almost entirely in the workshop, and whose theoretical knowledge—either of chemistry physics or mechanics—is almost negligible The German manufacturers of refractory materials on the contrary have almost invariably had a sound training in chemistry and engineering they approach the manufacture from an entirely different point of view namely that of the user turned manufacturer Consequently they are more impressed with the needs of the user while the British manufacturer is chiefly impressed with the difficulties of manufacture and the limitations imposed by his material If once this bias could be overcome—and the only remedy is the better education of the manufacturers—there is no question that better refractory goods can be made in Great Britain than can be obtained from the Continent for the same price.

* [illegible], in the *Journal of the Royal* [illegible]

The Educational Scrap Heap and the Blind Alley Job

A Vitally Important Economic and Social Problem

By L. W. Dooley

If there is one word in the English language which thoroughly designates the spirit of the modern age it is the word *efficiency*. In manufacturing, in merchandising, in philanthropy, in church, on the farm, everywhere we are convinced that preventable waste is a thing to be discovered, to be corrected. To many men the idea of efficiency is rather indefinite, meaning something above the average, but not capable of any precise definition. As a matter of fact, efficiency is very definite. It is the percentage of useful work or effect which is obtained by man or machine in comparison with what may be termed the maximum effect attainable. Manufacturers are not satisfied with the mere entering of raw material into the factory, and the finished product leaving by another door. They desire to know the amount of waste, and are very uneasy if too much raw material is wasted or placed in the scrap heap. Waste is repugnant to us to-day. This same cry of greater efficiency of the modern time has entered our educational system. Citizens and public spirited men are criticising our schools through the newspapers and magazines. They claim that there is great waste in our schools, the essential is neglected, and the boys and girls are not properly prepared for life. The practical abandonment of the apprenticeship in the country, except in a few isolated places like Brown & Sharpe Manufacturing Company, is bringing about a want of skilled workmen which the modern industrial system is failing to supply. On the other hand the great number of unskilled workers has increased, and all of them have not been able to obtain employment. The great industrial demand of the present, and of the recent past is making this want felt more and more sharply. The whole country is awakening to the necessities of the case, and demanding a remedy. Organized educational forces are moving rapidly in the direction of making our school system more practical.

With the idea of increasing the efficiency of our school system in this direction, a commission was appointed some six or seven years ago to investigate the need of practical education throughout the State of Massachusetts. The commission naturally first studied the need of industrial education in the great manufacturing centers. In the course of their investigations of the condition of the employment of children between 14 and 16 years of age, they found that nearly five sixths of the children in the mills have not graduated from the grammar schools, and a very large proportion have not completed the seventh grade, while practically none had a high school training. To be more specific a conservative estimate would be that every year in the State of Massachusetts from 20,000 to 30,000 boys and girls, on reaching the age of 14, leave the schools to go to work. This army is four times as large as the group which, at approximately the same age, enters the high school. Only one of every six of these children taking up some wage earning occupation has reached the eighth year or grade of the elementary schools, only one of every four has attained the seventh year, only one out of every two the sixth year. The record of the number of pupils that enter the high school and colleges in Massachusetts is as good proportionally as any State in the Union. So that above figures would be a conservative figure for the rest of the country.

In most States the law compels children to remain in school till they are fourteen years of age, and under ordinary conditions they should have completed the grammar school at the age of fourteen or thereabout. The question that comes to one's mind is, Why has not this child completed the grammar school before going to work?

The public school system is divided into divisions called grades, based upon the chronologic age of the individual. Pupils are graded in a school in order to keep as far as possible the mental and physical development equilibrium. A great many children of the same chronologic age may be safely placed in the same grade in the school, but since individual children differ from each other in mental and physical development to a marked degree, a wholesale classification has proved in many cases to be inadequate.

The different types of children may be illustrated by a straight line, one end of which might be called motor minded and the other abstract minded. The motor minded or hand mind child is one with a craving for achievement, to do and not to study. He has a natural dislike for books, and finds it possible to understand abstract principles only by having an actual experience with them. The abstract or book minded child is one who has no difficulty in committing to memory abstract principles and likes to study books. Between these two limits are shades of different types. The average child is motor rather than abstract minded.

The test for promotion in our present school system is a literary one. The abstract minded child with his quick memory has no difficulty in passing the promotional tests, while the motor minded child, without quick memory, fails of promotion and becomes what the teachers call a retarded pupil. A child repeating a grade feels that he is a social outcast among the pupils and loses interest in school. Then again, a child of twelve cannot be expected to be interested in the methods of teaching and content of information adapted for a child of ten.

There can be but little question that our school system has lagged behind the development of those forces of business organization with which they should be clearly articulated. Our school system is only just now entering upon the stage of efficiency which industry has long since considered. Nowadays educational experts are beginning to see that the dull pupils can be rescued and that stupidity has various causes, a great many of which may be cured. In years gone by, if a girl or boy did not get on well in school, he or she was most likely noted as being just plain stupid, and called a dunce, and allowed to drag along until the day came, when he or she would leave school. These children have been referred to as the scrap heap of the public school system.

Very wide and careful investigations have established the fact that a great many parents feel that when their children reach the age of fourteen they should go to work. The children in a few cases are not obliged to leave school because his parents are very financially able to keep him in school, but because they (the parents) went to work when they reached the age of fourteen, and they do not see how a further training in the public schools would aid their son or daughter in direct training for earning capacity. On the other hand the vast army go to work for economic reasons. This educational scrap heap, designated by our present school system as worthless, has great imitative power and capacity for mechanical work and experiences no difficulty in obtaining work at a high initial wage in what are called by our social workers "blind alley" or "dead end" employment, that is, employment such as messenger boys, attendants in bowling alleys, doffers in mills, attendants in glass factories, etc., in which the experience gained under the present industrial and educational conditions are said to form no basis for advancement into more skilled and better paid work as the child grows older. When these young men reach the age of eighteen they have passed their usefulness in this type of juvenile work, and find there are not positions enough for them in other parts of the mill, and they leave and form our great unskilled army, and fill our public employment offices. There are plenty of positions in the metal trade, etc., demanding mechanical experience that these young men might fill with profit if they had received a training on some kind of a part time basis while they were engaged in highly specialized juvenile occupation.

The problem to-day is how to retain our industrial supremacy, our present industrial organization of highly specialized work, and to develop the whole boy and girl so that we may have successful men and women with industrial habits to live useful and happy lives.

This cannot be done by groups of social workers in this country attempting to tear down our industrial system by forcing unjust legislation on the community such as compulsory full time education for children up to sixteen years of age or over. Our social and industrial system is a growth, and we are at the present time passing through the transition period of a change in our industrial and social system, the like of which has never been experienced in any equal space of time during the world's history. All this means readjustments of our social institutions, particularly the educational system. The school and factory must work hand in hand. The school must supplement the factory in such a way as to overcome the deadening effect of highly specialized work, and at the same time give a training that will develop the child so that when he has passed his usefulness in that juvenile work he may have the training and intelligence to enter other lines of work.

Any attempt to degrade our factory system, which employs practically two thirds of the children that have left school as soon as the law allows, by saying "it is ignorance on the part of the parents who allow the child to enter the mill or factory, and that neither power nor advantage is gained by entering the industry at an early age, and the child who does enter associates himself with our most undesirable population" is detrimental to the child and organized industry.

What a terrible indictment to place on our factory system. Let us examine it and see whether it is true or not. There are certain branches of industry, such as textile and glass, etc., requiring low or medium grade skill that are absolutely dependent for their operation on a supply of labor of boys and girls between the ages of fourteen and seventeen. A conservative estimate based upon reliable information shows that practically two thirds of the children that go to work after leaving school go to work from the immediate grammar grades in the above-named industries.

The textile industry employs more children at the age of fourteen or under than any other industry, and consequently is held up to the public as the most flagrant violator of child labor laws. It may be of interest to study the kind of juvenile work performed in the textile (employment) industries. Both boys and girls of fourteen or under can readily find employment in mills performing simple and easy operations such as doffing (replacing full spools on spinning frame with empty ones), piecing (placing broken ends of yarn together), supplying various adult machine operatives with bobbins of yarn, etc. These operations can only be performed to great advantage by children under seventeen. What they do receive in the line of learning is the development of useful industrial habits that are very valuable during the period of adolescence as they remain with the child.

In all these industries the work is intermittent, that is, it is of a character that allows for periods of rest and requires the attention of the operators for not more than two thirds, or half, the time; therefore, it does not require the consecutive labor demanding concentration, and the attention of the children and the care of the machine. Children at this age, between fourteen and seventeen, have not the endurance, that is, the bones have not developed sufficiently to allow consecutive work. To illustrate: the average boy or girl of sixteen or seventeen will actually give in work at least a half hour a day more than the average child of fourteen or younger. The child of the same age, sixteen or seventeen, will do at least 5 per cent more work, hour for hour, with a correspondingly less amount of waste material and damage to finished product. The work will also require less supervision, and will be of higher grade when finished.

That is the reason why the other so-called skilled trades, such as the higher branches of the metal and machine trades, the building trades, and printing trades, etc., do not care to receive boys or girls until they are seventeen. Girls find opportunities in skilled trades as typewriting, stenography, millinery, dressmaking, machine operators, and are not wanted until they are sixteen or seventeen. The above trades of high grade allow for individual action, the pupils have an opportunity to study their work and make comparisons between their past experience and their daily work. It also allows for the initiative and independence of the pupils and leads to a progressive development from a simple process to one requiring a higher degree of skill and intelligence.

Why cannot the factory system provide this training in the same way as some of the higher branches of the metal trades? Competition will not allow it. Greater changes have taken place in the organization of industries in the United States during the last generation since the factory system was introduced than during any other period in the world's history.

No industry shows this development better than the textile industry. During the past fifty-four years there have been practically no inventions involving new principles of textile machinery, but there has been marvelous improvement in the efficiency of the machinery.

In order to reduce our so-called educational scrap-heap it is necessary to change our school system so that it will educate the whole boy and girl of this day. A manual training department should be attached to every school in this country. Children should be taught as soon as they go to school to use their hands, as the father and mother did in the small communities a generation ago. It is very important that they should

be taught when they are young. The aim of all this will be to make every boy and girl, when they reach the age of fourteen, know how to use their hands with some degree of skill, to be "handy" in addition to the ordinary academic work. For the majority this will not necessitate any more hours of work (school). We have evidence that by reducing the time allotted to academic work and substituting manual work the mind will be stimulated. In addition, the child will not leave the school with a feeling of repulsion.

In order to look after the welfare of the individual child it is necessary to know definitely the time he should begin to work and the kind of work he is able to do. Physicians tell us that the mental and physical condition should not be overshadowed by being brought into use before the development adapted to such use is established; and on the other hand, that functions, both mental and physical, are weakened by not being brought into use when they are ready to be used.

This means that the mental condition of the child should be carefully determined to see whether the child should be allowed to work at all. Before this is done it is absolutely necessary to know the kind of work the boy or girl is to perform. After it is determined by tests that he has the mental equipment and the degree of knowledge necessary to do juvenile work, the next problem to be solved is whether his physical condition is such that this particular kind of work will not harm him. Since labor differs in character, occupations should be classified and the boy or girl should only be allowed to perform the character of work that is best adapted to his physical condition.

It is evident then, that some additional aid for determining the fitness of an individual, either for his school or physical work, beyond the usual superficial examinations now conducted for fitness, should be required. A very eminent physician of children's diseases, Dr. Thomas M. Rotch, has for some years been making a study of additional means of determining the relation of physical fitness to certain degrees of labor and to school work.

The close relation which is known to exist between physical growth and the development of the epiphyses led him to make some investigation by means of Roentgen ray on the living anatomy of early life during the different stages of development. A study of a large number of cases showed that under normal conditions all the centers of ossification progressed with comparative regularity, and that the degree of development of the wrists and hands represented to a fair degree that of the entire body framework. This correspondence of the development of the wrists and hands to that of the rest of the skeleton is especially fortunate, as it is evident that the wrists and hands are the most available parts for routine examination in a large number of cases. This anatomic relation has been substantiated by other physicians of high standing.

So that a more reliable and very practical method of conducting a physical examination may be substituted in which results will show whether the child has the proper physical development to perform physical work of a certain character. This method of physical examination is at present conducted by the United States Government at their naval academies.

The children who go to work in the mills leave school at a very tender age, a time when they have little liking for school or interest in the subjects they learn there. They have received absolutely no industrial training for the work they are going to do. The industrial operations of mills and shops of to-day are so highly specialized that the operators are not obliged to exercise any of the training they have received in school. The result is that they rapidly lose the habits of thinking and the power of initiative, and when they reach the age of eighteen, and cannot any longer perform the operations of doffing, etc., on account of the stiffness of fingers they become dissatisfied and leave the mill and form the army of the unskilled.

Before the advent of the factory system juvenile apprenticeship was common on the farm, the household, and in the trades. The child was taught the practice and theory of his trade. In addition to learning the orderly processes of his trade and seeing the necessity of continuous effort, he learned the practice of the small economies which are the basis of frugality and thrift. He learned to fit means to ends and become ingenious and inventive. He learned that when many worked together every little helped, and that only by mutual help could the best results be obtained.

We must act on the principle admitted by everybody who knows or cares anything about education, that the way to secure a good training for the mind is not to end the school life at the most plastic period, fourteen years of age, or in the case of foreigners, as soon as they can pass an examination, but to insist that every boy shall spend a certain number of hours a week under educational training and sound teaching till he reaches manhood.

Experience has shown that evening schools do not appeal to tired children. Boys between fourteen and seventeen have the "gang spirit" in them, and after working hard all day they desire companionship of their fellow workers on the street corners, or moving picture shows. Their eyes, wearied with long labor in the day, cannot endure the fatigue of book work by night, but they are revived and changed by the splendor of gay lights of the theaters and moving pictures. Physicians confirm this experience by stating that while these children require education, they should not attend evening schools after working nine or ten hours.

It may be said, therefore, that while we have built up in the industrial centers of the United States at an enormous expense a colossal system of education offering opportunity for a general education and prepare for admission to colleges and higher technical schools, we have failed to provide for the greater majority of boys and girls who enter industrial life in juvenile occupations. That is, a practical relation between industry and education for that great mass of pupils who are going to work with their hands as soon as the law allows. We allow the results of our educational system as far as these children are concerned, to be very largely wasted and lost. We cease to educate these all important years, during which we all know that education is most needed and valuable to our working people.

The German government has solved the educational problems in a more satisfactory manner than any other country. According to their scheme of education, every worker in a profession, trade, or commercial pursuit, must not only have a general education, but technical preparation for the particular work selected by him. In the United States we believe in the same policy, but apply it to those entering the profession only, disregarding the great mass—95 per cent—that leave school at fourteen.

Germany, by recent legislation, insists that every child be under educational influence till the age of eighteen. The child may leave the common school at fourteen. He may go to work, to a higher school and prepare for college or to a technical school. If he goes to work, he must attend classes called continuation schools, classes to the extent of eight or nine hours a week. In the United States he may leave school at fourteen, and is not obliged to attend any other school.

In order to overcome the educational weakness of our present dead end or blind alley occupations, we must provide for working youths opportunities on a part time system, an education which will meet with their interests and tastes, assisting each to become proficient in some line of work that he may enter after passing his usefulness in the so-called blind alley position.

Experience of educators in this country and abroad who have worked in large factory centers agree that it is a positive harm to retain the great mass of children between the ages of fourteen to eighteen in a school on a full time basis in spite of the many assertions from social leaders to the contrary. They have neither the mental equipment nor the interest to devote so much time to academic work. They have descended from ancestors that mature early in life and have intensely practical ideas.

Therefore, they should receive an education adapted to their physical and mental equipment—part time system of education. The educational training on a part time basis for boys in the so-called skilled occupations, where there are sufficient opportunities for them to remain all their life should be for greater efficiency and civic betterment. For the boy in the so-called unskilled or factory operations, where there is a lack for further advancement there should be a trade training so that he may receive during the years from fourteen to eighteen the beginning of a skilled trade, so he may be accepted into one of the skilled trades as a useful beginner. In this way the part time school acts as a port of entry from unskilled to skilled trade, and removes the strong feeling that exists to-day that our present school is undemocratic in that it takes care of 10 per cent in the community and ignores the 90 per cent who must work largely with their hands. It will meet the great educational needs of our splendid industrial system by supplementing the highly specialized experience with an antidote of more general practice and theory.

For girls in skilled vocations, the training must be for greater efficiency—a supplementary trade training in case of seasonable employments and a training in housekeeping. Since women have more or less to do with the home, it is doubtful if there is a more effective system of education than housekeeping. It will bring both health and happiness to the home.

The efficient democratic school of the future must have a course of study in the elementary schools that will be adapted to the aptitudes of the great mass of children who are motor minded and must be reached through the manual and objective methods of teaching. In this way pupils will be attracted to the schools and not leave as soon as the law allows. Vocational advisors should be established to assist and direct children in selecting vocations and while attending compulsory part time education. Intelligent selection of an occupation is the result of intelligent preparation. We cannot expect young people to find themselves vocationally without furnishing them with any raw material for thoughtful selection. Our public school system should audit our social accounts and publish the opportunities available to young people, that they may choose their life work scientifically, and in this way reduce our scrap-heap of unskilled labor to a minimum. Blind alley jobs will then become ports of entry into more skilled and profitable positions.

Trinitrotoluene in the War

In a recent article reference was made to the high explosives used as bursting charges for shells, the most important being the much-discussed trinitrotoluene, used largely by the Germans. The following summary, from *Nature*, of an able contribution on the subject, published in the *St. Thomas's Hospital Gazette* for December, will prove a useful supplement to the previous article.

Few people realize the exacting conditions which a high explosive for shells must fulfill; these may be summarized as high bursting power, stability in storage, insensitiveness to shock on firing from the gun and on impact of the projectile, where it is desired that penetration shall precede bursting. Yet it must be possible to cause the material which withstands such drastic treatment to detonate when required with frightful violence. It is a case of reconciling the irreconcilable. Further points are safety in handling in the shell factory and the suitability for producing maximum density of loading, say by some such method as melting and pouring into the shell.

The brisance, or bursting power, is shown to depend on the potential energy of the explosive, the velocity of detonation, and the degree of concentration (density of loading)

It will be realized that few substances will fulfill such conditions, and the number will be still further reduced by difficulties and cost of manufacture. The paper discusses the four most important explosives which have been tried for this purpose, namely picric acid (lyddite), trinitrotoluene (TNT), tetranitromethylaniline (tetryl), and tetranitraniline.

The trinitrotoluene is the symmetrical isomer (1 : 2 : 4 : 6) melting at 80.6. It is manufactured by dissolving *ortho*nitrotoluene in concentrated sulphuric acid, nitrating first to the dinitro and finally to the trinitro stage, the purification being effected by recrystallization from ethyl alcohol containing a little benzine.

Data are given of comparative trials of TNT and picric acid, both in France and Germany. In velocity of detonation and with the lead block test (increase in size of cavity on firing a charge) the advantage is with lyddite, as the following figures demonstrate:

	Lyddite.	TNT.	
Velocity of detonation	7,745	7,140	meters per second.
Lead block test	228	218	cubic centimeter.

TNT caused, however, a greater displacement of earth than lyddite when fired in a bore-hole 1 meter deep.

Except in the last instance, picric acid held a decided advantage throughout, and the question at once arises: Why, then, has trinitrotoluene been adopted by Germany, Russia, Italy, and other countries in preference to the picric acid that is still mainly used by us under the name of lyddite, and by France under the name of melinite? The struggle between the two explosives has been long and of doubtful issue, but it has now probably ended in the victory of trinitrotoluol.

In furnishing the answer to this conundrum the writer continues:

We have seen it to be inferior in regard to power, velocity of detonation, and density of concentration; its advantages lie in its greater insensitiveness to shock, its freedom from poisonous dust and fumes, the much lower temperature at which it can be poured into shells, and its chemical indifference to substances like lead and iron which are liable to form dangerous picrates. When firing a shell against a ship's armor, at certain limits of the thickness and toughness of the armor-plate and of the velocity of the shell's impact, picric acid would explode when trinitrotoluol would perform its work efficiently, and the latter is therefore better adapted to a high-velocity shell of large caliber.

Since TNT contains too small a percentage of oxygen for complete combustion, attempts to use it incorporated with bodies rich in oxygen, such as potassium chlorate, have been tried. The Belgian high explosive, "macarite," is stated to consist of 30 parts of TNT and 70 parts of lead nitrate. A very high density of loading is thus attained, but the velocity of detonation of macarite is given as only some 4,600 meters a second.

In concluding his article, the author says that tetranitraniline or tetryl seem to be the only known substances that may supersede trinitrotoluol.

Gyrostatic Action*

As Applied to Torpedoes, Submarine Craft and Aeroplanes

By Jas. G. Gray, D.Sc., F.R.S.E.

It is the object of the present paper to describe a number of gyrostatic devices available for controlling moving bodies. The gyrostatic motor cars and bicycles which are described in this and my previous paper to the Institution should be regarded merely as a kind of by-product; the real object of my work on gyrostatics has been directed to the production of gyrostatic controls for torpedoes, submarine craft, airships and aeroplanes. The motor cars and bicycles do, however, prove conclusively that the principles and methods of operation that have been evolved are dynamically correct, and that the application of these principles to problems of submarine and aerial warfare promises to result in the production of machinery of great value.

In all the cases considered in the present paper the stability of the gyrostatic system is derived directly or indirectly from the propelling system. Hence these cases do not include solutions of the monorail problem, for they have not true stability when they are at rest or moving in the backward direction. The tandem-wheeled motor cars to be described, for example, although they may be set to run in a perfectly straight path, will not balance on a single rail. The devices, however, have properties which are not possessed by any of the monorail devices so far evolved, and it is these very properties which promise to be of value.

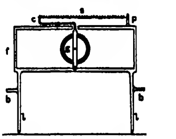


Fig 1.—Stilt top

In Fig 1 is shown a form of stilt top. A gyrostat is mounted as shown in a frame f. The gyrostat is on cross bearings carried by f. When f is upright these bearings are in a vertical line. The crank c, which is rigidly fixed to the frame of the gyrostat, is attached to one end of a stretched spring S, the other end of which is fastened to a point p in the main frame. If the fly wheel of the gyrostat is set spinning and the top placed on a table with the plane of the fly wheel and the main frame f in the same vertical plane, and left to itself, it will balance for a considerable time if the spin is great. Initially f is in the same plane as the spring S. The stretching force in the latter, therefore, exerts no moment on the gyrostat about the cross bearings which attach it to f, but as soon as the gyrostat precesses on the latter bearings the crank gets out of line with the frame and the spring exerts a moment in the direction of the precessional motion.

The entire top when vertical is unstable without rotation of the gyrostat fly wheel, about the line of contact of the feet with the table. Further, in consequence of the stretched spring the gyrostat is unstably mounted on the frame. Thus the gyrostat is doubly unstable without rotation of its fly wheel.

The action of the top is as follows. Starting with f in a vertical plane containing the crank and spring, suppose it to tilt over on the table. As a consequence the gyrostat precesses about the cross bearings, and the precession is aided by the spring, with the result that the frame erects itself into the vertical. But at the instant at which the frame has attained the vertical the spring is out of line with the frame, and is exerting a moment on the gyrostat. Under the influence of this couple the gyrostat continues to precess about the line of contact of the feet with the table; that is, the main frame passes beyond the vertical position, after which the lateral instability of the entire structure results in the establishment of a couple tending to accelerate this precessional motion. This couple causes precession about the cross bearings bringing the crank and spring into line with f, but when this alignment occurs the entire top is inclined from the vertical, and so on. The amplitudes of these oscillations continually increase, and finally the top falls over.

Again suppose that, starting as before with f, and the crank in one vertical plane, the crank gets out of line with f. As a result the spring exerts a moment on the gyrostat which, in consequence, precesses about the line of contact of the feet of the top with the table. This precessional motion is automatically accelerated, and the spring is thrown into line with f, which is now inclined from the vertical, and so on.

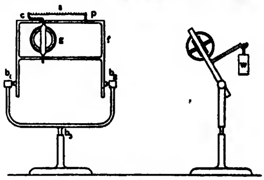


Fig 2.—Stilt-top set up on fork and pedestal mounting

It will thus be seen that starting with the main frame and the spring contained in one vertical plane the top balances, and if the spin is great the balancing power is very considerable. But there is not true stability; oscillations are set up. The frame oscillates to and fro on the legs, the gyrostat oscillates to and fro on the bearings which attach it to the frame. If the stability were real the top, if started in an inclined position, would erect itself into the vertical one with the spring in the plane of f.

It is interesting to consider the action of this top from the energy point of view. The entire structure is unstable on the legs, and thus possesses a stock of potential energy. Again, potential energy is stored in the spring. Obviously the entire stock of potential energy is a maximum when the top is upright with the crank in the plane of f. When the frame tilts on the legs, and the gyrostat turns on the frame bearings, energy is dissipated in friction. Consequently, once the frame has become inclined to the vertical, or the crank has got out of line with the frame, the system cannot return of itself to the position of maximum potential energy, that is, to the position in which the crank and frame are in one vertical plane. To obtain complete stability it is necessary that the energy dissipated in friction should be made good.

Returning now to Fig 1, it will be seen that the stilt top is provided with two projecting pieces b b. So designed it may be set up in a fork and pedestal mounting, as shown in Fig 2. The fly-wheel of the gyrostat is set into rapid rotation, and the arrangement mounted on the fork with the frame f and the crank in one vertical plane. The fork is grasped in the hand of the experimenter. Now, suppose the arrangement to tilt on the fork bearings b_1 b_2. The gyrostat precesses on the bearings that carry it on the frame, and immediately a couple, due to the spring, tending to accelerate the precessional motion, comes into existence. At the same time the experimenter turns the fork, so as to bring the frame into line with the crank. Providing this operation is properly carried out the frame is restored to the upright position and the crank is in line with it. The spring has supplied energy to the frame in restoring it to the upright position, and the potential energy lost by the spring has been made good by the experimenter. Thus the experimenter, by causing the frame to follow up any precessional motion of the gyrostat endows the system with complete stability.

Now, let a weight W be attached to one side of the frame. This at once causes precession of the gyrostat and the establishment of a couple due to the spring.

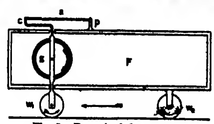


Fig. 3.—Two-wheeled motor-car.

The experimenter turns the fork so as to bring the frame into line with the crank. Here energy is being transmitted from the spring to the frame by means of the gyrostat, and at the same time energy is being supplied to the spring by the experimenter. The frame turns on the fork bearings, so as to raise the weight against gravity. The precessional motion continues until the center of gravity of the entire arrangement is vertically above the line of b_1 b_2. The spring is now in line with the frame, and consequently its stock of potential energy is precisely that which it possessed at the start of the experiment. The energy required to raise the weight against gravity has been supplied by the experimenter.

Fig. 3 illustrates the application of the principles just described to the construction of two-wheeled and four-wheeled gyrostatic motor cars. The figure shows a car in which the wheels, of which there are two, run in tandem. The gyrostat g is mounted on top and bottom bearings provided in the main frame F. One of the axles which carry the gyrostat is extended, and terminates in a bearing for one of the wheels W_1 of the car. The construction is such that this wheel is in the plane of the fly-wheel of the gyrostat. The back wheel is geared up to driving mechanism. The gyrostat is fitted with a crank and spring device, as already described. Arrows on the wheels indicate the direction of motion of the car.

Let the fly-wheel be set into rapid rotation, and the car placed on the floor with the main frame, the fly-wheel of the gyrostat, the two wheels supporting the device, and the crank in one vertical plane. It will be clear from what has been said that, if left to itself, the car will balance on the wheels, but with the accompaniment of gyrostatic oscillations of [illegible] increasing amplitude. If it were allowed to remain stationary the device would eventually fall over. But when driven in the forward direction it is completely stable. The gyrostat steers the car, and when precessional motion on the cross bearings takes place this results in the main frame F, to which the end of the spring remote from the crank is attached, being brought into line with the crank. Thus the action is precisely that described above for the stilt top when mounted in the fork bearings, but the action is now automatically perfect. The stability is complete when the car is moving in the forward direction. If a weight is attached to one side [illegible] the center of gravity directly above the line of [illegible]

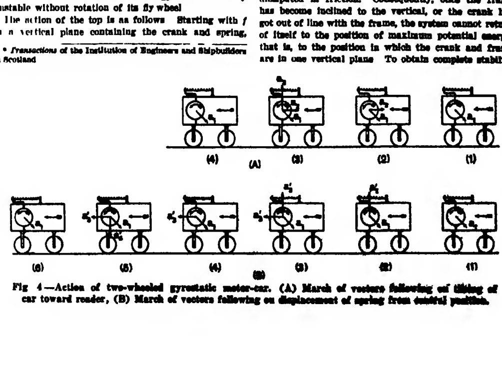


Fig 4.—Action of two-wheeled gyrostatic motor-car. (A) March of vectors following on tilting of car toward reader, (B) March of vectors following on displacement of spring from central position.

* *Transactions* of the Institution of Engineers and Shipbuilders in Scotland

the wheels with the ground, and thereafter proceeds in a straight line path.

In this device the gyrostat derives the stabilizing forces from the spring, and when the stock of potential energy possessed by the spring is drawn upon, an equal amount of energy is automatically supplied to it by the propelling system. The gyrostat thus detects any tendency to tilt in either direction, calls upon the spring to supply the necessary correcting forces, and upon the

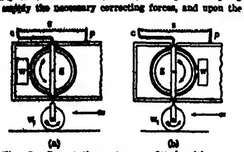


Fig. 5.—Gyrostatic motor-car fitted with controlling weights.

propeller to maintain constant the energy possessed by the spring.

The gyrostatic action of this device is illustrated graphically in Fig 4. Suppose the car to start perfectly balanced and upright. This condition is shown in (1) of the diagram (A) of the figure. The arrow at the back of the car shows the direction of motion, and the curved arrow attached to the gyrostat indicates the direction of rotation of the fly wheel. The angular momentum may be completely represented by a straight line drawn out from the fly wheel toward the reader. Thus a_1 is the spin axis. Now the car is unstable about the line of contact of the wheels with the ground, and hence, after a short interval, a tendency to tilt in one or other direction will assert itself. Suppose that when the car is in the position (2) there exists a tendency of the device to tilt towards the reader. This tilting couple is completely represented, according to the usual convention, by a line a_2 (the couple axis) of proper length drawn as shown in (2) toward the back of the car. The gyrostat precesses so that a_1 turns toward the instantaneous position of a_2, the crank comes out toward the observer, and a couple tending to turn the gyrostat counter-clockwise, as viewed from above, is established. This couple is represented by a_3 in (3). The gyrostat now precesses so that a_1 moves toward the instantaneous position of a_3, that is, the car erects itself against gravity, it moves away from the reader about the line of contact of the wheels with the ground. The tilting couple is thus reduced and finally annulled. Further, and this is a point of the greatest importance, in consequence of the fact that the gyrostat is steering the car, which is moving in the forward direction, the want of alignment of the crank and car is being reduced. Thus a_2 and a_3 diminish together, and the car is finally left as in (4) of the top diagram of the figure.

Now to investigate the annulment of the instability introduced by the crank and spring. This will be understood from the lower diagram (B) of the figure. In (1) the car is shown balanced in the upright position with the crank in line with F. Suppose it to get out of line with the car without there being any tendency of the latter to tilt (this may be due to a jolt). Let the displacement of the crank be towards the reader. The couple brought into existence by the want of alignment is represented by a_2 of (2), and the gyrostat turns so that a_1 moves toward the instantaneous position of a_2, the car turns over from the upright position (away from the reader) and a couple represented by a_3 of (3) comes into play. The gyrostat now turns on the vertical bearings in the direction which results in a_1 moving toward the instantaneous position of a'_3—that is, in the direction which brings the crank into line with the car. The couple due to want of alignment of the crank and frame disappears, but the car is left inclined to the vertical. This stage is shown in (4). The gyrostat is precessing on the vertical bearings, and a couple represented by a'_4 (5) is introduced. The resulting precessional motion and the forward motion result in a'_4 and a'_4 going out of existence, as already explained, and the device is left as shown in (6). It is now upright, with the crank and frame F in line.

A little consideration will show that the faster the car travel the more perfect is the action. As a matter of fact, the cars constructed by the author are perfectly stable even when moving very slowly. The action is, as already explained, quite automatic. Once the upright position is attained it is never departed from, and the car travels in a perfectly straight path. The effect of [illegible] tending to the car tending to upset it is to [illegible] which are quickly wiped out.

[illegible] have seen, the effect of attaching a [illegible] to F is to cause the car to bank up [illegible] straight path. The properties of the device are, however greatly added to by attaching a weight W to the frame of the gyrostat, as shown in Fig. 5 (a) and (b). If the gyrostat is spinning in the direction in which the wheels of the car rotate, the weight should be placed as in (a). If the direction is reversed the weight should be as in (b). Consider

Fig 6.

diagram (a). Let a side weight be supposed attached. The car banks up against this weight, with the result that the line of the frame bearings becomes inclined to the vertical. A couple acting against the spring is then applied by W. A steady state is soon arrived at in which the couples applied to the gyrostat by the spring and by W are equal. The car is not sufficiently banked up to account entirely for the side weight and the gyrostat precesses continually. The car moves in a circular path.

When the side weight is removed the device straightens itself out and proceeds in a straight path. Attaching the side weight to the other side of the car causes the latter to move in a circular path in the opposite direction to the former one.

Fig 6 is a photograph of an actual working model of a two-wheeled car constructed on the above principles. In this model the front wheel is the driven one. The gyrostat is carried on the main frame on vertical bearings. It steers the back wheel through a link attachment. The car is available for demonstrating the principles which have been explained. A much larger model provided with an electro-magnetic steering device capable of being actuated by the wireless transmission of electrical action has been constructed. It is housed in the Science Museum South Kensington.

(To be concluded)

The Effects of Bends on Electrical Conductors

In a short article in the *British Westinghouse Gazette* Mr P Jackson discusses the effect of bends and loops on the inductance of a conductor. It is frequently stated that the leads to and from apparatus—a lightning arrester for example—should be as straight as possible because short corners angles etc introduce an undesirable amount of inductance. This, Mr Jackson contends is not strictly true. The only reason for avoiding corners and bends, he points out, is that a crooked line cannot be the shortest one between two points. In fact, no matter how crooked and intricate the path afforded by a conductor, so long as one loop does not lie over another its impedance cannot be great er—and is in fact somewhat less—than that of the same conductor stretched out straight. Those who have been in the habit of looking upon loops and bends in

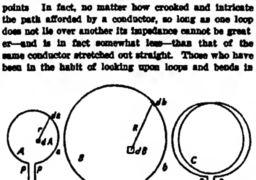


Fig 1

conductors as detrimental from the point of view of low inductance may feel inclined to reject this statement, but in support of the argument Mr Jackson puts forward the following illustration. The inductance of a single turn of wire in the form of a circle is double that of a similar loop of half the diameter. Consequently for similar loops the inductance is proportional to the length of the wire, in other words, the inductance is the same per foot of wire.

If the loop be made very large, then a small section of it is approximately a straight line, and its inductance may be considered to be equal to that of a straight wire. Hence the inductance of a foot of wire carrying a given current is the same whether this wire forms part of a small loop or a large one or a straight conductor. The diameter of the wire however has an effect which has not been considered and furthermore the statements do not apply to coils in which there are two or more turns. For the statement to be strictly true the diameter of the conductor must vary with the size of the loop. If not, the inductance increases slightly more rapidly than the linear dimensions of the loop.

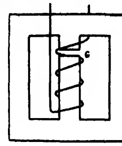


Fig 2

Neglecting this however the statements may be taken as correct. Assume that loop B in Fig 1 has twice the linear dimensions of loop A and of course an area four times as great. Suppose the area of A be divided into say 1 000 little portions dA and the circumference into a smaller number of short arcs da. We can divide up the loop B into the same number of portions and dB will of course have four times the area of dA and db will be twice as long as da. Now db being twice as long as da the magnetic effect of current flowing through it at any point will be twice as great. Small elements also like dA and dB will be magnetically affected by da and db inversely as the square of their distances from one another.

In general since the linear dimensions of B are twice those of A distance R will be twice as great as distance r and the magnetic effect of a given current in db on dB will be one half that of a similar current in da and dA. However the area of dB being four times that of dA and its flux density one half as great it will contain twice the flux. There being the same number of elements dA and da as there are dB and db the same conditions holds for the whole circles or loops of what ever shape so long as they are similar. In other words the flux for a given current varies directly with the dimensions of similar loops and coils and the inductance is the same per unit length of conductor.

Now suppose that loop B were many times as large as loop A so that a length of such conductor equal to loop A from p p would be practically a straight line. Neglecting the influence of the size of the wire which was referred to above, its inductance would be the same as loop A. Thus loop A from p to p has no greater inductance than the same conductor stretched out in a straight line. In other words bends loops and corners are harmful only because they involve more conductor and not because such loops and bends in themselves increase the inductance. But this is not the case if one loop overlaps the other as shown on the right of Fig 1. In this case the inductance increases in general as the square of the number of turns. Sharp points are bad whether at bends of the conductor or elsewhere but for reasons due to the static rather than the magnetic field. The production of magnetic lines around a conductor or through a coil by magneto-motive force is analogous to the flow of current through a resistance as the result of an electromotive force. In one case the flow of energy is proportional to the value EI, E being the pressure and I the current and in the other case the stored energy is proportional to the value HB, H being the magneto-motive force and B the flux density. With a given loop or coil if H be doubled by doubling the ampères B will also be doubled and their product or the stored energy will also be four times as great. The same is true if the electromotive force applied to a fixed resistance be doubled—the energy input is quadrupled. If a coil of given shape has the number of turns doubled the value of H for the same current is doubled and the magnetic reluctance remains the same so B is doubled and HB or the stored energy is quadrupled. In this case also, as the stored energy per unit current is quadrupled the value of L or the coefficient of self induction which is a measure of this value is correspondingly quadrupled.

This fact that the stored energy is proportional to HB develops another fact which is sometimes unsuspected. Take a coil such as that shown in Fig 2 with an iron flux path. If there is no air gap the flux per unit current is greatest, but the stored energy for a given flux is not. If an air gap G be introduced the value of H must be largely increased on account of the reluctance of the air gap. The stored energy HB then becomes correspondingly greater. If the coil is in a series relation to the circuit it is most effective if the air gap G is just large enough to permit saturation of the iron circuit.—*The Engineer*

The Future of the Police Arm*

Considered from an Engineering Standpoint

By Henry Bruere[1]

The author states as his reason for a discussion of the problems of police administration at a meeting of mechanical engineers that the most neglected field of public service in America is the police department. There is no part of municipal administration not itself in the engineering category that more urgently needs the aid of engineering methods than does the police arm. He makes this assertion on two assumptions with which he says there may not be general agreement. The first assumption is expressed in a definition of the substance of the engineering method. The second assumption is expressed in a definition of the functions of the police arm. These definitions are as follows:

a. The engineering method consists of applying scientifically determined knowledge to the execution of a particular problem and the use of ordered and analyzed facts as a basis for formulating conclusions in respect of that problem. As a result of the repeated application of the engineering method to like or similar problems a technique is established for achieving a particular object repeatedly with least waste of energy and resource.

b. The function of the police arm of government is to ascertain all the facts regarding the phenomena of crime and disorder and by the use of those facts as a basis for action direct and collateral to minimize and extirpate crime and disorder.

In respect to the functions of the police arm the author says that generally until now the functions of the police have been assumed to be something as follows:

a. General enforcement of certain laws and ordinances.

b. Enforcement of certain other laws and ordinances selectively according to the feasibility of their enforcement and the state of public opinion regarding them.

c. Enforcement of certain other laws and ordinances on complaint of persons injured by their infraction with particular respect to the perpetrators of the injury.

d. Repression or prevention of crime and disorder by the process of tacit intimidation, in other words the brass buttons and swinging night stick.

e. Physical and militaristic suppression of express disorder such as riots and street brawls.

f. Investigation of crime committed for the purpose of tracing, identifying and apprehending the criminal.

g. Performance of inspections, regulation of traffic, rendering aid to citizens and miscellaneous other incidental functions that are committed to the police as matters of convenience and are not generic to the police problem.

The one common ideal of police service that has been developed in American cities is that the police must be physically well-conditioned and personally honest. This is about as far as any American city has gone, with the possible exception of Toledo under the rule of Brand Whitlock and New York city to-day under the administration of Mr. Mitchel and Mr. Woods.

In the minds of the conventional police criminals divide themselves into four groups:

a. Aliens, enemies of society violating the rights, safety and peace of a community, to be put away, thus gotten rid of.

b. Native incorrigibles endowed with natural perversity, namely the familiar thug, the gangster, the crook.

c. Fortuitous criminals who become subject to police action because of moral lapse or temporary aberration.

Or as belonging to

d. A miscellaneous group including special and individual cases too numerous to catalogue, but comprehended generally in 174 items of the standard crime classification as used, for example, by the New York police.

There has been no recognition of crimes as the consequence of remediable social conditions or the effect of individual abnormalities either physical or mental resulting from removable causes.

There should, however, be a statistical basis for police work as there is a statistical basis for engineering work. There is nowhere in the world a collection of social data so potentially useful to the development of a community as lie in every great municipal police department in the records of arrests, in the records of crime disposition, in the investigation of crimes, in the note-books of policemen and in the memoranda and reports of detectives.

In the report of the New York police department for 1913 the only reference to these records is found in a single sentence under the heading Bureau of Records: "During the year 1913 there were received and filed in the Bureau of Records a total of 35 013 documents."

New York city employs 11 000 policemen who made 119 736 arrests in 1913. It has a detective bureau of 150 detectives who investigate 55 000 cases of crime a year, but it has not a single employee engaged on an analysis of the facts brought into the archives of the department in the form of reports on investigations and records of arrests. Commissioner Woods is the first police commissioner in America, so far as the author knew, who has thought it worth while to put in his budget a request for statisticians. Next year he will have a statistician under the supervision of a deputy trained in statistical analysis who will study current police conditions and police work. Not only is he taking this step, but he is utilizing every member of the force as an agent for gathering social facts respecting such matters as unemployment, destitution, improper guardianship, upon which intelligent police work must be predicated.

While it is generally known that economic distress and unemployment lead to an increase of small crimes against property and the breakdown of natural self-control, no American police department has ever analyzed its records to correlate degrees of unemployment with perpetration of crime and thus furnish the basis for police activity with regard to unemployment. New York city, however, has had this matter forced upon its attention. Conditions of unemployment last year furnished the opportunity for anarchistic agitation, demonstrations of violence, invasions of churches and other disorderly practises, on the avowed theory that only in this way could the public be brought to realize the crucial importance of unemployment conditions.

These violent manifestations of disorder which had their relation to conditions of unemployment occurring in 1914 make it seem a natural function of the police to ascertain the facts regarding conditions of unemployment in 1915. The police department is the logical agency to call the attention of the community and other branches of the government to the need for taking some constructive steps to mitigate abnormal unemployment.

In New York one of the principal problems confronting the police is control of traffic. It was never conceived by the builders of modern cities that thoroughfares intended for residential purposes and often crowded with children would be utilized by high-powered motor trucks and automobiles, and that many streets designed for local traffic would become the thoroughfares of a vast population. As a result of this condition there are killed each year in the streets 445 persons.

It is peculiarly the function of the police department to work out means of preventing this appalling condition, because the police department is charged with responsibility for regulating traffic. Up to January 1st of this year New York city's police did not record information necessary for an intelligent analysis of the conditions surrounding the death of persons in the streets, although they are required to report the facts regarding each occurrence as a part of the coroner's investigation.

By focusing the attention of police captains and patrolmen on the incongruity of using congested traffic streets for play spaces for children, the present police commissioner obtained from patrolmen and their officers suggestions concerning the use of vacant lots for play purposes and for closing to traffic during certain hours of the day streets used by children for play. The mere fact that the police themselves formulate such suggestions and assist in putting them into effect, brings about a psychological change in the attitude of the policeman to his community relationships which is full of the greatest possibilities for the development of police service. It is merely another illustration of applying the scientific or engineering method to a particular problem, instead of continuing along from generation to generation with fatalistic resignation to whatever may happen.

The author anticipates possible criticism of his suggestions that they overlook the necessity for dealing with criminals as criminals and maintaining law and order by vigorous police action. It is no part of this suggestion that law enforcement be relaxed. A sentimental attitude towards breakers of the law and violators of the public peace and social rights of the community is not advocated. On the contrary, a very drastic action is favored regarding them where such action does not defeat its own purpose. It is recognized that the existing product of social environment, of disease, of mental degeneracy, of moral perversity, cannot be dealt with through eliminating conditions which breed them, but have to be dealt with through our penal machinery and will probably sooner or later, for the protection of society, become the subject of police action.

A very considerable part of present criminality can be eliminated by intelligent preventive action. This preventive action should be initiated if not actually taken by the police. To initiate it intelligently, the police must act not on general information or impressions but on carefully gathered data. These data will not in every instance point to clear conclusions or be capable of definite analysis. The work of correlating crime to social conditions is practically untried. If law and order be at the basis of industry, if social adjustments are essential to economic welfare and civic development, then no section of the community can ignore the police problem. It is particularly important that engineers who are the expert advisers of our industrial and economic life should make their special experience available to police administrators in formulating a method for arriving at the facts underlying the police problem.

The latter part of the paper deals with police organization. Involved in this are questions of training of officers, selection of officers, ratings for efficiency and selection for promotion, enforcement of discipline, methods of compensation, welfare activities, including educational work, medical supervision and provision for insurance and pensions. These various questions are discussed briefly. The author says further:

The outstanding fact regarding conventional police organization is that it is military, and the outstanding fact regarding military organization is that it is not intended to accommodate itself to shifting social development, to relate itself intimately to community life, to be sympathetic and understanding, or to be flexible. Military organization deals with individuals as subservient members of a group and not as self-governing factors co-operating in the execution of an undertaking. In police departments it has aimed at the one consideration everywhere recognized as fundamental in police work, namely, personal integrity. The military assumption of moral and mental dependence of subordinates on superior officers has, however, been one of the great weakening forces of police work. In the case of policemen personal integrity results from exercise of self-restraint in inhibiting an impulse to accept a bribe, to connive at a violation of the law, or to practice extortion. The faculties needed to resist temptations of this character must be developed through a process of self-reliance, through a formulated, even though rudimentary, philosophy of personal conduct. The soldier ceases to be responsible for his moral conduct once he places himself under the command of a superior officer. This condition, while of course less marked in police service than in a purely military organization, still prevails to a certain degree, and has been a conspicuous embarrassment to the development of individual police initiative in larger American police departments. Mr. Woods, New York's present police commissioner, has no military training or sympathies, and is dealing with the officers and men of his department on the assumption that they are self-controlling and self-initiating centers of police thought and police work. This method is a promising contrast to the policy of the martinet, or a policy of easy tolerance, that customarily prevails in police work, and stands out against the old conditions as strikingly as the modern, enlightened employer's policy in industrial management does against the old time shop boss method of dealing with workmen.

The future development of the police arm, if police work is to be constructive and to fulfill its possibilities, must be along the lines of the engineering method. The police department through its multitude of agents is the best equipped of all social agencies for apprehending sympathetically and certainly those adverse social conditions in the community which can be remedied only through community attention. The police department should be the eyes, ears and feeling fingers of the city government. If it finds through its investigation and observation that repression facilities are inadequate,

*Abstract of paper and discussion presented at the Annual Meeting of the American Society of Mechanical Engineers, and published in their *Journal*.

[1] City Chamberlain, Municipal Building.

that this bears upon crime conditions and the welfare of the city's youth those facts should be driven home to the educational and recreative departments and in the same way with other conditions

The police department of a great city should be the nerve center of the city's government capable of acting with vigor when a situation demands vigorous treatment, strong to protect the safety of the public against disorder and the unruly informed on conditions which manufacture crime and criminals in order that these conditions may be remedied where remedies are possible, aggressive instead of defensive courageous instead of fatalistic organized for achievement instead of for mere opportunism, militant but not military except in the sense of obedience to necessary rules and responsive to discipline free to deal honestly with conditions in the light of those conditions instead of in the light of statutes written by dead hands co-operating intelligently with charities corrections, health hospitals and educational departments

To bring these things about the police problem must be broken up into its proper functional divisions Crime when perpetrated by professional criminals must be dealt with differently from crime committed by those who stray temporarily from the paths of rectitude There should be organized a national service for the detection of criminals and crime prevention along the lines of similar service now engaged upon forestalling and detecting counterfeiters The voice of the police department must be heard in the courts when punishment is meted out to criminals not because it is the police department but because it is informed and expert on questions of penology

Above everything else back of police work there must be developed a scientific spirit the true engineering spirit in place of cunning and cudgels there must be substituted a policy based upon a knowledge of needs standards of service feasible of attainment and organization devices to accomplish them methods of administration and the plant to facilitate their accomplishment and the genius to capitalize the initiative and individuality of every man on the force

DISCUSSION

Clement J Driscoll Bureau of Municipal Research New York city in a written discussion said that the cause for police inefficiency in New York can be found in the fact that in 13 years the department has had ten police commissioners Not one of these doubted the efficiency of the engineering methods and not one did not fully realize before he retired or was forced to retire from the department that the police problem was such that only careful patient application of scientific methods would solve it All of them would say to the engineers gathered here that all the methods known to science would be of little value while the control of the department was in the hands of the political powers of a community The Panama Canal one of the supreme engineering feats was made possible only because the engineer in charge remained on the job long enough to work out the engineering problem But even Mr Goethals would not have mastered the police problem of New York by the application of the engineering method if he had been subjected to the conditions under which all the administrative heads have had to work No matter how determined a police commissioner may be to keep his department free from politics it will be subjected to a political influence so long as he himself is subject to arbitrary removal and the mayor of a city is held responsible for a police department

In summarizing he urged as the first step toward increasing the efficiency of the police the adoption of statutes providing for a more permanent tenure of office for the administrative head second the complete separation of the police department from the mayor's office placing the full responsibility for the administration and conduct with the police commissioner or administrative head regardless of his title third the application of the engineering method and fourth the complete abolition of the system now in vogue throughout the country of adopting policies of law enforcement which will result in the enforcement of the statutes as written

Thunder*

Theories, and Experiments Conducted in an Endeavor to Solve the Problem

By Dr Wilhelm Schmidt

ATTEMPTS to explain thunder and lightning have heretofore generally been based upon a study of electrical sparks in the laboratory Although much valuable information has been obtained in this manner we should be cautious about assuming that the results deduced from such experiments apply to the gigantic operations of nature as it is easy to overlook factors that occur in one case and not in the other For example the discharges occurring in these laboratory experiments are generally oscillatory and it has commonly been assumed that the same was true of lightning discharges However Dr B Walter of Hamburg with the aid of his rotating camera has obtained convincing proof that lightning is mainly unidirectional A lightning flash begins with a preliminary branching spark that penetrates only a short distance along the ultimate path of the discharge this is followed after a brief interval (of the order of 1/100 second) by a somewhat longer discharge etc until finally a path is built up for a complete discharge which again is intermittent in character An even more striking proof of the difference between laboratory experiments and actual lightning is seen in the fact that the question of protecting buildings from lightning still remains unsettled opinions differing both as to the possibility and method of securing protection

In a like manner the conception of thunder as merely a reproduction on a large scale of the crackling or detonation of the sparks used in the laboratory needs to be confirmed by a study of the natural phenomenon more especially as very few attempts in this direction have hitherto been made In this study we may take as point of departure two important facts viz the brief duration of the phenomenon and the great accumulation of energy in a small space that it involves

On account of the latter there is a strong repulsion of electrified air-particles of like sign and therefore a sudden increase of pressure in the path of the spark H Mache and E Haschek have found a pressure of more than 60 atmospheres in the case of a spark 3 millimeters long, though this was in part the result of the vaporization of material in the electrodes A wave set up by this increase in pressure spreads out in all directions This is not an ordinary sound-wave as the fluctuations of pressure are not small in comparison with the normal pressure, but a so-called "explosion wave" such as is observed in certain rapid and violent chemical reactions Such explosion waves, which we perceive as a report spread with a velocity that may be much greater than that of ordinary sound-waves, but are transformed into the latter as their intensity rapidly diminishes, owing according to Tumlirz, to the separation from them and lagging behind of secondary waves Experiments of Mache with "schlieren" and interference methods in connection with electrical sparks show plainly the sudden initial push, a condensation of air, then a longer and feebler wave of rarefaction, and finally, in some cases, a number of smaller waves

To assume that the same conditions apply to thunder, recognizing merely a greater intensity of the phenomenon, is not admissible without some further investigation, as in this case it is only rarely and under exceptional circumstances that we hear an actual report which is the distinguishing mark of an explosion wave Direct investigations of thunder are therefore necessary

For this purpose we have used two forms of apparatus one for the analysis of regular sound waves and the other for that of the longer pressure waves The former a modification of Marbe's apparatus[1] records the atmospheric impulses in the form of fluctuations in the deposit of soot from a flame upon a rapidly moving strip of paper The latter registers the displacements of an extremely light disk which hangs before an orifice opening into a box enclosing a large volume of air these movements are magnified by a suitable mechanism and the apparatus is provided with a time-scale Both instruments were kept ready for use so that registration could begin as soon as a thunderstorm occurred

The records from these devices showed that regular trains of waves of uniform length practically never occurred and hence that the thunder had no proper tone but was merely a noise and the records also showed that it was quite similar in character to the rattling of window panes The irregularity of the waves was greatest during the heaviest part of the thunder—i e at the moment of the clap —while toward the end of the thunder in many cases a certain degree of regularity was noted A statistical analysis of the frequency with which waves of various lengths occurred showed a preponderance of those lasting 1/40 second or more and again of those lasting between 1/120 and 1/75 second (i e vibrations of such length that if they had occurred in uniform trains they would have produced the tone F_1 or lower or again tones between D and A) Shorter waves most common in music were much rarer

The records of the second piece of apparatus showed that the greater number of the longer waves are in fact so long that they are imperceptible to the ear Their duration was mainly between 1/10 and 1/3 second In one case the duration was 0.54 second

The fluctuations in air-density occurring in connection with these waves were far greater than those occurring in ordinary sound waves or in the more rapid audible waves pertaining to thunder (Vibrations at the rate of 20 to the second may be assumed as the lower limit of audibility) Although the lightning was never near at hand—the interval between the flash and the beginning of thunder being mostly about 5 seconds—the records showed pressure fluctuations amounting as a rule to more than 0.01 millimeter Hence the greater part of the total energy of thunder is represented by these long inaudible waves which must be regarded as the essential part of the phenomenon and thus strange as the statement may sound, we may say that one really hears only the smallest part of a clap of thunder Most of the phenomenon either escapes our senses altogether or is perceptible only through the vibration of objects around us the rattling of window-panes etc In the immediate vicinity of the electrical discharge these pressure fluctuations are evidently, extremely violent, and a great part of the purely mechanical injuries wrought by lightning must be ascribed to them

The number of these violent waves is however never large In most cases they occur in irregular series of three or four in various parts of the thunder In the heaviest thunderclaps perceptible as such to our senses where the waves have generally traveled only a short distance and reach us but little modified there is usually but one violent wave viz at the very beginning Here we have complete agreement with what has been said above about explosion waves and from this fact we may draw certain conclusions

We are to conceive of a shock wave (*Stosswelle*) as traveling in all directions from the path of electrical discharge The prolongation of the phenomenon depends in the first instance upon the fact already mentioned that the discharge is frequently intermittent and may therefore set up several initial waves but more especially upon the occurrence of shorter audible waves which separate from the initial waves gradually increasing the magnitude and duration of the disturbance at the expense of its intensity The duration is further prolonged by reflection—not so much from clouds and sheets of falling rain as from the interfaces between atmospheric strata of different temperatures—and especially by the action of the wind The original sharp report is transformed into a "roll" or is sometimes divided into two or more claps Irregular short waves which give the rattling noise of nearby thunder are gradually lost in the more regular waves so that in distant thunder the sound may assume a more or less definite pitch

Whether the energy of the electrical discharge alone is sufficient to produce these phenomena is a question that can be answered without difficulty The energy of thunder as shown by the analyses of our records amounted in a maximum case to 22 000 kilogrammeters and was therefore very great compared with that of ordinary sounds In this case the thunder lasted 13 seconds and it would require more than 200 000 000 buglers blowing for the same length of time to produce an equivalent amount of energy Nevertheless this amount is insignificant compared with that of a flash of lightning for which we may assume and not in extreme cases something like 10^{10} kilogrammeters In fact only a small part of the energy of lightning is transformed into pressure-waves and sound most of it assumes other forms such as those of heat and light

We have still to consider the question of the rolling of thunder as related to the length of the lightning path In connection with the common idea that the sound reaches the observer first from the nearest part of the path and last from the most distant part and that the duration of the thunder depends upon the resulting interval of time the following facts should be borne in mind Assuming as a first approximation the case of a uniform impulse along a path free from sharp angles we shall have only a single wave spreading in all directions and the observer will perceive only a single brief sound whose time of occurrence will depend upon his distance from the nearest part of the lightning-path This follows directly from the Huyghenian theory of wave-motion Moreover bends in the lightning path will account only for a limited number of "claps" and not for the "roll" of thunder.

[1] A substitute for the manometric capsule, described by E. Marbe in Phys. Zeit., 7 1906 p 543 fig —TRANSLATOR

* Abridged translation from Die Naturwissenschaften

NEW BOOKS, ETC

UNIVERSAL SAFETY STANDARDS. A Reference Book of Rules, Drawings, Tables, Formulæ, Data and Suggestions for Use of Architects, Engineers, Superintendents, Foremen, Inspectors, Mechanics and Students. By Carl M. Hansen, M.E. Compiled under the Direction of and Approved by the Workmen's Compensation Service Bureau. New York: New York Universal Safety Standards Publishing Company, 1914. 12mo.; 312 pp.; illustrated. Price, $3 net.

The earlier edition of this work was so well received that it is now issued in a revised and enlarged form, embodying suggestions applicable to special industries. Of the four divisions of the work, the first summarizes general safety standards, showing by lavish illustration their application to plant and machinery. Part two takes up the machine shop, part three the foundry, while the final division suggests rules and practices for employees. The method of illustration followed is to show the machine or part in black-and-white line drawing, with the safety device in vivid green. Thus the eye is at once led to the source of danger and to the means of guarding against it. By the co-operation of employers and employees along the lines laid down in this work, very large percentages of human injury and economic waste might easily be averted.

UNIT PHOTOGRAPHY. By Frank Morris Steadman. New York: D. Van Nostrand Company, 1914. 8vo.; 160 pp.; 13 plates, 10 illustrations. Price, $2 net.

Mr. Steadman's researches seek to place the practice of photography upon a more scientifically exact basis. He points out that fundamental elements, such as the chemical energy of light, the relative aperture of a lens, and the sensitiveness of emulsions, still lack simple units of measurement. When such amateur work as is given over to the professional for development records a complete failure in from 70 per cent to 80 per cent of exposures, any system that will materially reduce these failures should be welcomed. The author suggests such a system in what he has termed "Unit Photography," in which he takes up the determination of units of measurement of light comes and of their photographic intensity, and considers the character of photographic emulsions and the speed of plates. His theories and methods are thoughtfully presented, and should substantially contribute toward establishing both amateur and professional photography upon a more accurate footing.

POOR'S MANUAL OF RAILROADS OF THE UNITED STATES. Forty-eighth Annual Number. New York: Poor's Railroad Manual Company, 1915. 8vo.; 2060 pp. Price, $10.

This valuable annual publication deals in an authoritative manner with the entire railroad business of the United States and Canada, also Central America and Mexico. Details are given as to the trackage owned, acquired by lease, proprietary lines, electric lines, boat lines, etc., as well as a complete history of the various roads, the rolling stock, general income, additions and betterments, comparative operating statistics, dividends, capital stock, transfer agents, funded debt, quoting debt, board of managers, and officers. Thus for the New York Central and Hudson River Railway Company and controlled railways we find 104 pages devoted to this system. Excellent maps are scattered throughout the book. The amount of information which it contains make its compilation a vast undertaking. This is a very handsome piece of book making.

THE WORLD ALMANAC AND ENCYCLOPEDIA, 1915. New York: Press Publishing Company. Price, 25 cents.

To attempt in the limited space at our command a description of that treasury of statistics known as the World Almanac would be vain as it would be needless. Everyone knows its wide scope, its great fund of accurate information, and everyone turns to it for the support of their arguments and the settlement of disputed questions. With all the usual tables brought as nearly as possible down to date, and with many new and vital subjects included, it should extend still further its circle of friends. The field of scientific research, religion, politics, education, athletics, financial and national defense—to name but a few of the zones of human interest it invades—are ably covered.

INSTALLING EFFICIENCY METHODS. By C. F. Knoeppel. New York: The Engineering Magazine, 1915. 4to.; 258 pp.; illustrated.

In this very attractive addition to the "Works Management Library" the author assumes that others have ably established the desirability of the higher efficiency; he contents himself with describing the actual methods employed and their practical working out. The volume begins like a novel. We find the Enterprise Manufacturing Company in difficulties, the employment of an efficiency engineer is suggested, and the suggestion carried in the face of strong opposition. The way in which the expert attacks the problem and the successive steps taken by him to eliminate friction and lost motion in the organization, the management, and the men, are described in a happy blend of bright, attractive narration with shrewd diagnosis and sound remedial measures. These practical working instructions and explanations should prove invaluable to the owners and managers of non-modernized undertakings. It is impossible but that they should find much in the work that is applicable to their own problems and to some extent dissolvent of their own peculiar difficulties.

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SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, MARCH 13, 1915

Charles Allen Munn, President
Frederick Converse Beach, Secretary
Orson D. Munn, Treasurer
All at 361 Broadway, New York

Entered at the Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year		$5.00
Scientific American (est. 1845)	"	3.00
American Homes and Gardens	"	3.00

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SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX NUMBER 2046

NEW YORK, MARCH 20, 1915

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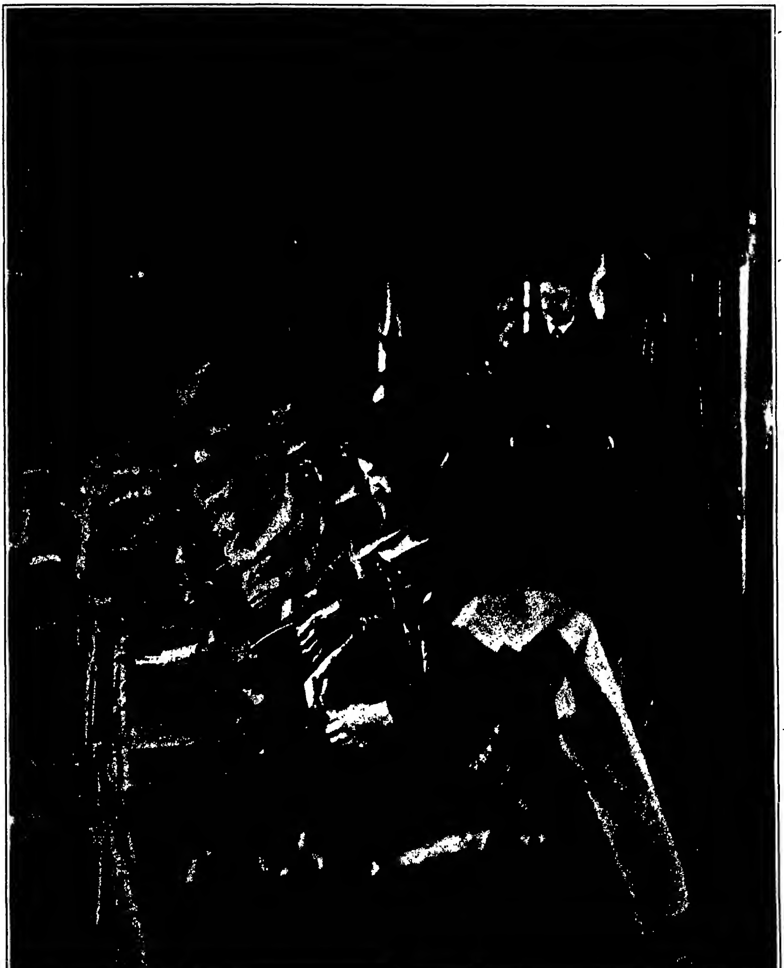

Grinding and sharpening blades on the mill stones.

THE CUTLERS OF THIERS.—[See page 184.]

Modern Ideas on the End of the World

New Contributions to Cosmology Obtained from the Development of Differential Theories

By Gustav Jaumann, Professor of Physics at the Technical High School at Brunn

We are totally ignorant of the beginning of the world. During the last century the hypothesis of Laplace and Kant that the planets proceeded from the sun and were at first formed by the condensation of it enjoyed wide credence. According to this theory our earth was once in a state of glowing liquid. Judging by the increase in temperature in the deep strata it is covered at the present time by the solidified crust relatively very thin, which we live. Such a conception has rendered plausible belief in the deluge and in the idea of a final day of judgment when the world will be devoured by flames.

Geology indeed records horrible catastrophes; the highest mountains were formed by a single short earthquake of tremendous violence, the result of upheavals of granitic magma. By enormous volcanic eruptions erratic blocks were carried thousands of kilometers. In particular the whole of Asia suffered the invasion of the Indian Ocean which was precipitated on the continent with inconceivable violence sufficient to carry the rhinoceros and the mammoth which are considered Indian animals as far as the frozen fields of Siberia. Cuvier affirmed not only that the world would be destroyed some thousands of years hence but that it has already many times undergone like cataclysms, each geologic formation constituting the burial place of a creation entirely separate in origin. According to this hypothesis the termination of each geologic period has been marked by a complete ending of the world and the opening of each succeeding period by a special creative act giving birth to a new fauna more perfect but equally incapable of evolution. By the side of the brilliant Cuvier lived obscure and unknown the much greater Lamarck. It is he who recognized the continuous evolution of the faunas in accordance with an immanent law or at least in consequence of the capacity which organisms possess of perfecting themselves by assiduous exercise and by communicating in part to their descendants the improvements thus acquired. It is this way of thinking which after a turn toward Darwinism has finally established itself. Now to permit such an evolution of the organic world from the beginnings to its actual perfection requires a considerable duration of cosmic quiet. Geologic investigations since Lyell have indeed demonstrated that the passage from each geologic formation to that succeeding it is made gradually and without interruption. The inundations and volcanic catastrophes which are produced at all times far from destroying worlds have never been more than purely local. Volcanic eruptions are not the index of a fluid and incandescent nucleus, for the accumulations of liquid lava have little extension so that even neighboring volcanoes such as Vulcano and Stromboli have no relation to each other. One can even affirm that the fluid incandescent nucleus of the earth does not exist. Recent physical observations especially those relative to the transmission of the transverse seismical waves through the interior of the earth and to the period of migration of the terrestrial axis admit of the conclusion that the earth in its entire mass is as elastic as a steel of good quality.

But now we must observe the very disquieting previsions of the exact sciences. These we must notice particularly for physics and astronomy have exact natural laws and in this way may be predicted in all probability the most distant consequences for the laws which are concerned here that of gravitation and that of the conservation of energy are among the ones most firmly established.

The real achievement of Newton was to show that the law of gravitation had a more exact application than the laws of Kepler according to which the planets move along their elliptical orbits.[2] In reality the planets do not describe strictly elliptical trajectories. The form and the position of these trajectories change constantly although with extreme slowness. The law of Newton affords an explanation of the greater part of these divergences, if the reciprocal attractions of the planets are taken into consideration. Taking these deviations into consideration, it is possible at present to calculate to within a few seconds the positions of the sun the moon and the planets a hundred years in advance. But to determine at a distance of millions of years the end of the Newtonian world enormous mathematical difficulties must be overcome; indeed, it is a matter concerning the problem of the stability of the planetary system and of calculating whether the disturbing influences weak but incessant, which the planets exercise upon each other will nearly counteract each other in time or will end by entailing the destruction of the planetary system.

Eminent scholars have always taxed themselves with resolving this fundamental problem relative to the stability of the world. Laplace and Lagrange showed, by means of an approximate calculation that the planetary system of Newton appeared to be stable. Poisson demonstrated that by further refining the calculation later epochs could be surveyed in which greater and greater fluctuations in the form of the planetary orbits were present. Finally Poincaré proved that by carrying the calculation to its limit a future time was disclosed in which the planets would experience unlimited progressive so-called secular disturbances and finally some of them would fall into the sun, and others lose themselves in the cold of cosmic space. Thus the planetary system of Newton has no stability no internal constancy. But the foregoing calculations were made on much too favorable a basis. Cosmic space can not be empty as Newton held. Since it can transmit light, it must be filled with a medium extremely tenuous and cold called cosmic ether. The extreme vacuum obtained in the laboratory cooled to —170 deg. Cent. presents a considerable viscosity which is only ten times inferior to that of the normal air.[3] Consequently the cosmic ether must oppose to the movement of the planets a very appreciable frictional resistance. They must continually lose energy of motion in addition to which the attractive action of the sun becoming more and more considerable the planets should describe orbits more and more narrow and should end in some millions of years by precipitating themselves into it. Thus again we have the igneous death of the earth. But that end would be preceded by the destruction of the terrestrial organisms all being menaced by death from the cold which would set in much earlier.

The energy thrown out with the sunlight is several billion times greater than the total interchange of energy which takes place on the earth. The sun gives off continually enormous quantities of it, and its supply, of whatever unknown kind it may be, must finally be exhausted. It would cool down more and more and our civilization after terrible struggles would meet with disaster more and more amidst the ever-present ice.

Thus the two fundamental physical laws lead, it is seen to essentially gloomy consequences, but, with all the respect that is due to their sublime results and to their precision, it is only right to ask whether they are really established with such ideal exactness as to enable one to draw conclusions applicable to epochs immensely remote and to comprehend the very plan of creation. Before accepting these consequences it will be well to submit these inexorable laws to a much more searching scrutiny. That the law of gravitation will not support an examination carried to extreme limits, nearly all astronomers agree in admitting. The most striking deviation from this law is offered us by the moon, which undergoes an inexplicable acceleration, not less than 6 seconds per century. An analogous anomaly, more marked and still more considerable, has also been recognized in the motion of Encke's comet. The orbit of Mercury presents an inexplicable perihelion rotation, attaining 40 seconds per century, and its eccentricity is not augmented with the rapidity which the law of gravitation demands. The orbit of Mars is subject to anomalies of the same nature, while the inclination of the orbit of Venus increases inexplicably by 10 seconds every century. Terrestrial gravity presents even from the point of view of direction, a diurnal and annual oscillation of a fraction of a second, which is not to be explained alone by the attraction of the moon or of the sun.[4] It is true that these are relatively small and isolated deviations, and that in general the law of gravitation suffices for the calculation of the motions of the stars with a sufficient approximation, always assuming that the cosmic ether is absolutely devoid of friction. This latter, however, is far from being accepted by physicists. When one considers that the periodic comets, even the smallest ones, apparently undergo no frictional resistance, that they are capable of penetrating the solar corona at a speed of 5,000 kilometers per second, without undergoing appreciable loss, one is obliged to admit that the law of gravitation is not sufficient, but that forces unknown, though hinted at by Kepler, act upon the stars in motion, and tend to offset the effects due to friction of the cosmic ether. It is a fact that no trace, however slight, of a beginning of the falling of the planets toward the sun, as the law of Newton predicts, has yet been shown. The same may be said of the cooling of the sun, which should follow in accordance with the law of energy. It was supposed for a long time to be self-evident that the climate of the earth had grown constantly cooler, but this idea has been entirely abandoned. Fluctuations less than 10 deg. Cent. on both sides of the mean temperature have often occurred, several times in Europe, thus placing these regions now under tropical conditions, and now under the conditions of the Arctic Zone. But from this point of view the most remote ages of the geologic history of the earth differ not at all from the present epoch. Glacial formations, extensive but not thick, have been found in early Cambrian strata.[5] At that time the temperature was not higher but lower than in our epoch, and more than a hundred million years have passed since then.

One can with difficulty admit of the existence in the sun of a supply of energy able to endure without appreciable decrease, for so long a time, the enormous expenditure due to radiation. The stability of the planetary system and the inexhaustible luminous power of the sun are, furthermore, to a certain extent verified by direct geologic observation.

How is it that the law of gravitation and the principle of the conservation of energy fail so entirely in their prophecy concerning the end of the world? What is the hidden defect of these laws which, as the foundations of physics, have given such magnificent results within narrower limits, and how can they be given an entirely correct form?

Regarding these really fundamental questions of theoretical physics, I feel myself called upon to speak, in so far as they fall within the field of my own studies. I should point out, however, that questions are concerned which are far from being decided and that I can state here only [illegible] hypothesis of the [illegible] of a [illegible] body [illegible] [illegible]

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* Inaugural address of the rector of the Imperial German Franz-Joseph Technical High School at Brunn delivered on October 20th 1912. Translated from the German in the annual report of the Smithsonian Institution, published by the technical high school.

[1] In this connection we designate as Darwinism only that part of Darwin's teachings which originated with himself, not the evolution theory which is due for the most part to Lamarck but rather the theory of selection according to which there could not be any evolution of the organic world without the influence of selection in connection with the struggle for existence.

[2] The law of gravitation itself was not originated by Newton but by Kepler whose ideas exerted a powerful influence on Hooke, Halley and Fermat. It was first formulated mathematically by Wren whose physical work was otherwise unimportant. Newton only contributed proof of its correctness. Kepler originated the fundamental and extraordinary new conception. "Virtutem quae planetas movet, residere in corpore Solis" ("The power which moves the planets resides in the mass of the sun"—heading of ch. 33 in Kepler's "Astronomia Nova." See Jo. Kepleri Opera Omnia," Frisch's edition, vol. 3, p. 300). He also originated the idea of the field of gravitation in which the force diminishes with the distance from the sun and the idea of universal gravitation. Had Galileo's dynamics controlled Kepler as it did Huyghens, he would not have needed half his genius to have anticipated Newton's contributions to the subject.

[3] This extreme vacuum of —170 deg. Cent. has the modulus of viscosity 3 × 10⁻⁶ c. g. s. To overcome the resistance that the ether offers to our earth would require more than 150,000,000 horse-power. Meteorites must glow in the ether, if their diameter be less than 20 centimeters. As a matter of fact, a glowing meteorite has been observed at a height of some 700 kilometers (above Sitka on September 9th, 1908, reported by G. von Niessl in [illegible], Kayser, vol. 17, p. 312, 1878, and even in the spectrum of the comets when approaching perihelion (where their velocity is greatest) clear indications of the glowing of solid bodies have been observed.

[4] [illegible]

[5] [illegible]

[illegible] by a state of tension, and that the [illegible] of [illegible] another were propagated [illegible] from one particle to the particle [illegible] adjoining it. It is thus that the elementary [illegible] is always produced in ultimate particles situated in the magnetic field, and its law is a differential [illegible] expressing the relation of cause and effect between the existing conditions and their causative predecessors in each ultimate particle of the space. It is from [illegible] between all the ultimate particles of the magnetic field in the so-called integral that the effect at a distance results. Maxwell established the laws of effect from point to point of electromagnetism (or differential laws of the electromagnetic field) which with an admirable simplicity not only explained the electromagnetic phenomena formerly known (which the laws of effect at a distance were equally capable of doing), but did much more; they predicted indeed the propagation of electric vibrations through space in the form of electromagnetic rays. The luminous rays appeared thus as electromagnetic rays. Hertz obtained, with purely electromagnetic resources, electromagnetic rays of great wave length, and Marconi has utilised these same rays in wireless telegraphy. Thus it is that one of the greatest and most difficult advances in the theory, the transition from laws of effect at a distance to theories of effect from point to point, led immediately to a great technical advance.

At that time (more than 20 years ago) many physicists, Hertz and Mach in particular, recognized that the real object of the theory was to explain physical phenomena by differential laws, a task which seemed to pass much beyond the attainable, but it has been in large part satisfactorily performed[1] since at present the law of gravitation itself can be expressed in the form of a law of effect from point to point.[2] The end sought in this connection consists in dethroning the old corpuscular and mechanical theories still so full of vigor. The list of facts brought forth by the two contending parties increases in length from year to year and the struggle between phenomenalistic investigation and mechanical investigation is waged on a field of great extent, embracing almost the entire domain of the exact sciences. The combat centers around the question of the nature of light and of the cathode rays.[3] The new theory of gravitation is only a partial victory on the extreme wing, but by virtue of it we now have exact notions regarding the manner of propagation of gravitation through the cosmic ether. The anomalies of the field of gravitation compensate each other in cosmic space according to a law analogous to that which rules the irregularities of the distribution of temperature in a good conductor of heat. It is only for stars in repose that the Newtonian law of effects at a distance follows exactly from the differential law of gravitation.

Now the motions of the planets produce disturbances, a kind of damming up so to speak, of the field of gravitation in front of the moving stars, giving birth to new forces of gravitation added to the Newtonian forces. Although very small it can be determined with precision that the most important among them has the same direction as that of the motion of the planet to which it is a stimulus. It increases with the speed of the planet and varies in inverse ratio to the distance separating it from the sun. These new forces of gravitation introduce into the planetary movements disturbances which can be calculated without difficulty and even cause the deviations from the Newtonian law which we have mentioned above. By them are explained the anomalous perihelic rotations, accelerations, oscillations of the vertical, etc.—that is, all the phenomena of gravitation without any being left over, which the Newtonian law of effects at a distance was incapable of doing. These new forces of gravitation moreover give to the planetary system a physical stability of unlimited duration. They keep the planetary orbits in their present form, not only in spite of the very considerable resistance due to friction of the cosmic ether but also in spite of enormous accidental disturbances. If a disturbance of this nature (which might be due, for example, to the passage in the neighborhood of the solar system of a fixed star imbued with a very rapid motion of its own) should be produced and modify entirely the form of the planetary orbits, the new forces of gravitation would introduce into the elements of the orbits such variations that these planetary orbits would gradually return exactly to their existing stable form. Far from becoming dangerous the frictional resistance of the cosmic ether, on the contrary, helps essentially to make the planetary orbits stable. The greater this resistance the more considerable become the new forces of gravitation and the more obstinate the planetary orbits in conserving, in spite of all the disturbances, their stable form. Thus there can no longer be any question of the planets dropping into the sun. Far from being unstable, far from tending toward a destruction more or less remote, the planetary system is then established for a duration which, estimated according to the ideas of time that we are able to conceive, may be considered as eternal.

The absolute validity of the principle of the conservation of energy is incontestable but its new differential form[10] leads in entirely new directions. The cause of the indefinite constancy of the temperature of the sun rises from the inevitable reaction of the differential law of gravitation on the law of the propagation or radiation of energy and in particular the differential law of the conduction of heat, established by Fourier. The forms of the two differential laws must be placed in opposition to each other in order, when taken together, to correspond to the principle of energy. The very considerable rôle which the mass of bodies plays as the cause of the concentration of the forces of gravitation demands a corresponding influence of the mass of bodies on the concentration of energy. To the radiation of energy called the flow of heat there corresponds a new flow of energy in the direction of gravitation. Thus the law of the conduction of heat established by Fourier is strictly applicable only to media of extremely slight density. In dense substances there must be a hitherto unrecognized concentration of energy, and this is not an hypothesis but simply the balance of the system of laws of effects from point to point. All dense bodies should in consequence produce heat incessantly and spontaneously. All bodies are so many radiations functioning without loss although in very different and to us generally imperceptible degrees. Far from being in contradiction to the principle of energy, this fact springs exactly from its expression in the form of the law of effect from point to point. The salts of radium indeed produce a similar effect of spontaneous radiation, but this is of such an exceptional intensity that it has amazed the physicists. Upon its discovery doubts were conceived of the validity of the principle of energy, but it is only the integral form of the principle which gives place to these doubts, while the differential form, or the law of effect from point to point, is thus all the more firmly established. The increase of temperature in the deep strata of the earth is explained by this effect of spontaneous radiation without the intervention of the hypothesis of deposits of radium. Moreover, there is produced toward the sun an enormous concentration of the new radiation of energy arising from the field of gravitation, which compensates for the loss of energy which the sun undergoes and assures the permanent constancy of its mean temperature. Consequently the sun yields no energy at all to the wide circle of cosmic space; that which it radiates into cosmic space is recovered in the form of this flow of energy from the field of gravitation. The senseless waste of the sun's energy, of which the theory of effects at a distance seems to prove the existence, is shown by the theory of effect from point to point to have no place in nature. A cooling off of the sun will not bring the development of our civilization to a stop, after which, through the deterioration of the climate, it will disappear and the last men will live like Eskimos on the entirely glaciated earth. The radiation from the sun being stable, the intellectual and physical evolution of humanity will be able for an immeasurable time to mount to heights surpassing perhaps anything the imagination is capable of conceiving.

Thus, as a result of the development of the differential theories, a new and unsought contribution to cosmology of high and moral, also essential, value has been obtained.

[1] G. Jaumann, A complete system of physical and chemical differential laws, Sitzungsber. K. Akad. Wiss. Wien, Math. Naturwiss. Kl., vol. 120, pt. 2a, 1911, pp. 385-530.

[2] G. Jaumann, The theory of gravitation, Sitzungsber. K. Akad. Wiss. Wien, Math. Naturwiss. Kl., vol. 121, pt. 2a, 1912, pp. 95-182.

[3] The majority of physicists still subscribe to the emission theory of cathode rays (the corpuscular or emissional theory) and there is a tendency, under the leadership of Einstein and Planck, toward giving up finally the essential features of the classical theory and going back to a sort of emission theory of light.

Regarding the undulation theory of cathode rays and the phenomenalistic undulation theory of light in dispersion media, see G. Jaumann, The electromagnetic theory (Sitzungsber. K. Akad. Wiss. Wien, Math. Naturwiss. Kl., vol. 117, pt. 2a, 1908, pp. 379-643), which paper was rejected by the editors of the Annalen der Physik in 1908 and in 1911 was honored by a prize by the Imperial Academy of Sciences in Vienna. See also E. Lohr, The boundary conditions in G. Jaumann's electromagnetic theory (Sitzungsber. K. Akad. Wiss. Wien, Math. Naturwiss. Kl., vol. 120, pt. 2a, 1911, pp. 1503-1567, and vol. 121, 1912, pp. 633-678.

[10] G. Jaumann, Sitzungsber. K. Akad. Wiss. Wien, Math. Naturwiss. Kl., vol. 117, pt. 2a, p. 385 et seq., vol. 120, p. 398 and p. 505, vol. 121, p. 169.

The Conditions of Industrial Accidents*

The enactment of laws in various States on workmen's compensation for injuries has aroused increased interest in the statistics and physical and psychic conditions of industrial accidents. The total number of these accidents is almost appalling. The lowest estimate places the fatal accidents to adult workers in the United States at 25,000 a year, with an additional [illegible] non-fatal accidents. The Massachusetts Industrial Accident Board, on the other hand, placed the number of workers killed by accident yearly at 75,000, which apparently includes not only adults, but also workers of all ages; while the number of injured of the same [illegible] was placed by this Massachusetts authority at [illegible] or even. An earthquake in a foreign country [illegible] half this number of persons and [illegible] injured in our United States [illegible].

[illegible] of these accident [illegible] proportion of accidents [illegible] day of the [illegible] fatigue. [illegible] should [illegible]

contention though it has been disputed. In the Massachusetts Industrial Accident Board Reports, in which the official figures are given, there is scarcely more than one twentieth more accidents on Monday than on Tuesday, while Tuesday is not much above the average in the number of accidents reported for other days. Saturday, of course, shows a noteworthy reduction because of the half holiday in some trades.

By far the larger number of accidents occur at about 10 A. M. and 3 P. M. This fact is confirmed by the reports of two State boards, Washington and Massachusetts, which have secured rather careful records. As they represent the extremes of the country the conclusions from their statistics would seem to be incontrovertible, though the fact is not what might naturally be expected. The State of Washington Industrial Commission[1] says, "These results seem to disprove the theory that fatigue is the prominent cause of accidents because accidents are here shown to happen at the hours when the workmen are least fatigued." On the fatigue theory it might naturally be expected that most accidents would happen after 11 A. M. and 5 P. M. The actual hour of the high point of the curve of accidents shows how important are the facts and how necessary of proof the theories.

After much discussion, the tendency to speed up employment has been incriminated, as the predisposing condition for the occurrence of accidents. This desire comes over the workman when he is not yet fatigued, but has been employed for several hours. He starts the morning's work cold, and as he warms to his work the danger of mischance because of haste becomes greater. Just when the speeding up reaches a climax in the morning hours most accidents happen. The same thing is true in the afternoon. Workmen feel sluggish after their lunch, but after an hour of work warm up again and by about 3 o'clock they are doing their most rapid work and are at the same time more subject to accident.

With regard to accidents among children, however, there is no hour of maximum. Accidents occur at all times and they are comparatively much more frequent among children than adults. The United States Bureau of Labor reported that "there is clear evidence of great liability to accident on the part of children. Though employed in the less hazardous work, their rates steadily exceed those of the older co-workers, even when in that group are included the occupations of relatively high liability." This was said with regard to the Southern cotton mills, but the same thing is true of practically all industries in which children are employed.

The results of these accidents come to the physician. We are devoting much time to the prevention of disease, and we should be ready to give attention also to the prevention of injury. Virchow used to say that the ideal function of the physician, besides that of reliever of human ills, is to be the attorney of the poor for the prevention and relief of social ailments, and, above all, the prophylaxis of their physical consequences, whether in lowered health or in maiming injuries.

[1] Report of Bureau of Washington Industrial Commission for 1913, p. 375.

Gardens of the Zoological Society of London

Its History, Organization, and Its Valuable Collections

By R W Shufeldt

As is the case with all the achievements of man museums zoological gardens and aquariums have each and all had their beginnings. Some of these latter have been of extremely modest pretensions while in the case of others the starting has been upon a far broader basis and the enterprise given an initial impulse through the influence of powerful patronage and munificent financial support which in any particular instance has at once placed the institution in the foremost rank with others of its class. In the present article it is not my intention to have anything to say in regard to any museum or aquarium these subjects will be taken up later on but I propose to point out some of the advantages of a first class zoological garden and for this purpose I have selected the Zoological Gardens of London as my example.

Plan of the gardens of the Zoological Society in London

South entrance to the Zoological Gardens.

Let me say at the outstart that these Gardens belong to the Zoological Society of London an organization of world wide reputation which was incorporated by Royal Charter as long ago as the year 1829 having for its main object the advancement of zoological science—a mission which it has most efficiently performed for a period extending over three quarters of a century. Personally I have always taken an active interest in the welfare of this Society and as I have been one of its corresponding members for nearly 30 years I am more or less familiar with its history the history of its gardens and with the enormous influence the two combined have had in promoting the best interests of the science of zoology throughout the civilized world. While it did not receive its charter until 1829 these gardens were first opened to the public a year before that time or on the 27th of April 1828. This statement however will by no means enlighten the reader upon the highly interesting question of the origin of these gardens—a point I desire to refer to before passing to matters of a more recent nature.

In order to discover how zoological gardens first came into being—if one be so fortunate as to ultimately obtain such information—it behooves the searcher to scan the historical records having reference to them and it will soon be discovered that the most valuable of these date from the time of remotest antiquity. Such tracing quickly carries one into the musty tomes of the fabulous ages where traditional history soon becomes obscure and the thread of investigation is lost. In those archaic times collections of living animals were known as menageries and in the main they consisted of collections of large mammals (and sometimes birds) obtained by the monster-queller who for that purpose accompanied the armies of invasion in the days of ancient Greece and Rome. These nations in many respects were barbarians in those days and most of us know of the brutal and fiendish uses to which these captive lions and bears tigers and leopards were put in the public arenas and in the dungeons of the cities of the conquerors.

Still as the years passed by these very early nations with all their cruelty and barbarism in time presented the evidences of the dawn of thought and observation. Individuals appeared from time to time who in an era of increasing leisure devoted themselves to philosophic studies of their environment and in this was included the wild and captured animals which came within their ken. Sentimental as this movement was at first it speedily became the foundation for more exact zoological research and the dawn of scientific investigation set in.

Thus it stood in later Greece when the Macedonian conqueror Alexander led his victorious armies eastward even to the very banks of the Indus. Never did he allow an opportunity to pass through which he might further the aims of science or add new animals to the marvelous menagerie he had already formed at his native capital. Aristotle his old friend and tutor took up the serious study of these treasures and reveled in the extensiveness of the undescribed material at his hand. In due course it bore its fruit and the world was given one of the most original and greatest zoological works of the period Aristotle's *History of Animals*.

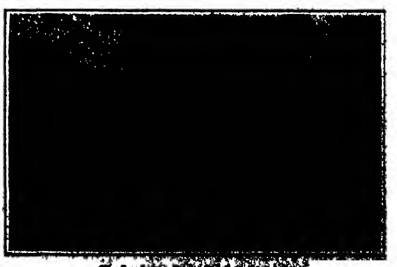
A somewhat similar growth of natural science took place in Rome during the same period but along different lines here the public menageries were replaced by the private *vivaria* supported by individuals of leisure and affluence. The later Caesars were then in power, and during their regime, Pliny produced that very [illegible] and marvelous production—his work on the natural history of animals. As we are now aware, every page of its reeks with error, or is rendered worthless through the flagrant introduction of the fabulous and the ridiculous.

But we are not concerned with these writings here, or with the extraordinary times during which they appeared, I aim but to refresh the mind of the reader with respect to the origin of menageries in ancient Greece, and the formation of the *vivaria* in early Rome. For fully fifteen centuries thereafter there was no building up anywhere in Europe of a menagerie or a zoological garden while the entire science of animal history was steeped in fable and shrouded in the rankest atmosphere of ignorance.

It was not until Louis the Fourteenth founded and sustained a menagerie at Versailles that the interest in such institutions was again revived on the Continent, and writers once more appeared to take advantage of what was at hand for them—that is, a large and varied collection of captive animals, and such other material as the early museums there supplied. The *Natural History* of the highly imaginative Buffon followed, as did, about the same time, the far more exact work of Daubenton—respectively the Pliny and Aristotle of those later times.

In London—very early London—was the Tower Menagerie which may be said to have been the ancestor of the present Zoological Gardens of the Zoological Society of London at Regent's Park. This Tower Menagerie possesses a wonderfully interesting history, and one I may say, far too extensive to be touched upon in this article. In 1826 there was an admirable collection on public exhibition there consisting of a large number of very valuable animals, some of which, later on, found their way into the present "Zoo." There were about sixty different forms, chiefly mammals, while there still remained with them a number of birds and reptiles—among the former a great horned owl and among the latter a

The Fellows Pavilion and the bear den.



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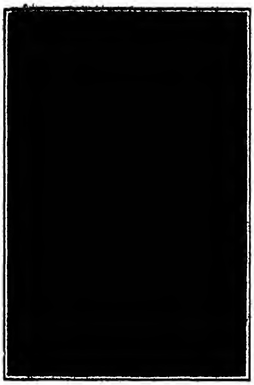


The white pelican

rattlesnake, these in evidence of the fact that even at that early day, upwards of a century ago wild forms were being obtained in America for exhibition in London.

The Zoological Society as now organized consists of nearly 4,400 Fellows and, taken together of some 300 Foreign, Honorary and Corresponding members There is elected annually a council which governs it and King George who has been a Fellow since 1894, is its patron The Duke of Bedford is its present president and its secretary is Dr P Chalmers Mitchell F R S At stated intervals it issues *Proceedings* and *Transactions* the latter being a sumptuous publication in which has appeared many of the most famous zoological contributions in the English language Reports upon the animals of the "Zoo" appear as a rule in the *Proceedings*

Among other buildings there is a fine library and offices at Regent's Park, which is located at No 50 as shown on the accompanying plan I may say in passing that all the views shown of the park and its buildings in this article were kindly made for me by Mr F W Bond F Z S the official photographer to the Society, who has a wonderful collection of photographs of animals which have been kept at the Zoo, all secured by himself

These London gardens occupy but a small extent of ground in the very heart of the city There are not over 34 acres in all, though the views would lead one to suppose that the place was considerably larger As will be seen by the accompanying plan the grounds have been admirably laid out, and that with the view of making the many inmates as comfortable and contented as possible, compatible with the economical apportionment of space As a property, these gardens are held from the Crown, through the Office of Woods and Commissioner of Works, at a fixed annual rental

It is scarcely necessary to say that there is a distinguished staff of naturalists connected with these gardens, and a very large body of workmen employed to perform the many duties associated with such an extensive institution Some of England's greatest scientists have, in the years gone by, been connected in one capacity or another with the "Zoo," and the extent of the published researches made by them is one of the grandest monuments that has ever been erected to biological science.

Hundreds of animals of all kinds are upon exhibition there at all times, and the list of those which have been kept there in times past is not only enormous, but includes nearly all the forms known to us—that is, in so far as the vertebrates are concerned. Each year the "Reports of the Council and Auditors" are published, [illegible] which [illegible] is to [illegible] For ex[illegible] living in [illegible] 1913 was 2,[illegible] December, [illegible]

[illegible]

dis in the collection as well as researches upon their anatomy, both normal and pathological Mr F E Beddard, F R S is the present prosector and Mr H G Plimmer, F R S the society s pathologist An enormous quantity of excellent work has been done here which for years past has been published in the society s *Proceedings*

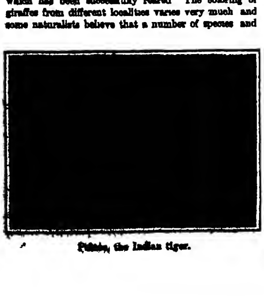
The admittance to these gardens is quite special as a charge is made for admission of one shilling for adults and a sixpence for children On Mondays however and on certain advertised days it is sixpence for everybody and on Sundays the gardens are closed except to Fellows and their friends who gain admission with special tickets

The society publishes an official guide-book which is not only beautifully illustrated with pictures of a large number of the animals—half tones from photographs—but it prints a great quantity of information about them as to their habitats habits in nature breeding and much else besides Some of these accounts are more extensive than one finds in works on natural history and certainly more trustworthy

Under the giraffe-house for instance (No 62) we read in this guide that The first living giraffe which is known to have reached England was sent to his Majesty King George IV in the year 1827 It lived two years and two months In the summer of 1836 four giraffes from Kordofan reached the gardens safely These succeeded in the most remarkable manner and no less than seventeen individuals were bred in the Society s gardens from these animals or their descendants In 1881 the last survivor of this stock died but the Society was able to purchase other examples and to exhibit them until the last died in 1892 At that time and for some years afterwards the Soudan was practically closed because

The Southern giraffe

of the rise of Mahdism and the next arrival was a fine young female imported from South-east Africa which however died in 1907 A pair of giraffes from the Egyptian Soudan was presented to the society by Col Mahon the governor of Kordofan in 1902 and from these was born in September 1907 a young female which has been successfully reared The coloring of giraffes from different localities varies very much and some naturalists believe that a number of species and



Pitnim, the Indian tiger.

The Beisa oryx

perhaps two genera should be recognized All the principal mammals and birds in this guide of over 100 pages receive such notices as the foregoing so that the body of information thus presented is both valuable and instructive

As I know from personal experience the Society is very glad to receive at any time living animals for its menagerie and these are invariably fully acknowledged in its annual report in the year in which donations of the kind come to hand I usually send such animals by express in properly constructed cages and I have thus succeeded in transporting different species of turtles horned toads an Arizona squirrel and so on The list of such donations during a year usually number several hundred from all sources Occasionally these are of unusual extent and correspondingly valuable as for example when the King last year presented the gardens with the Nepal collection consisting of 48 large and rare mammals and 1[illegible] birds while the Duke of Bedford and the government of the federated Malay states presented during the same year many animals of the greatest value

The installations of such collections as those at the gardens form occasions in which the royal family not only take part but greatly excite the interest of the public afterwards For instance in the case of the King s Nepal donation it is reported that The collection on board the British India Company s S S Afghanistan reached the Royal Albert Docks on May 20th and arrived at the gardens before 8 P M The animals were at once installed as all arrangements had been made for them and they were on view to visitors on May 21st The King and Queen and Princess Mary visited the gardens on the afternoon of May 31st to inspect the animals By the King s wish the visit was strictly private and no special preparations were made

As will be seen from Mr Bond s interesting photographs some of the views in the London gardens are very attractive and along the canal and elsewhere one can hardly realize that the places are in the very heart of the largest metropolis in Europe

The entire management of these gardens is carried out along strictly scientific lines and under a plan of management which appeals to anyone who appreciates extreme tidiness system and proper presentation of the animals he resorts there to study and such a one cannot fail to be encouraged by the knowledge that behind it all science is constantly utilizing the material through published papers and reports to the advancement of civilization and to the national credit of the country sustaining the institution

Efficiency of Coal and Electric Heaters

Concerning the importance of efficiency of electric and fire radiators but little general information has been given out In some recent experiments it is stated that an electric lamp radiator gave out 548 watts, against 1 060 put in, or an efficiency of 52 per cent On the other hand a fire radiator produced 727 watts out of 1,570 put in, giving an efficiency of 46 per cent. There are, however other questions than those of comparative efficiency to be considered, as, for example first cost and cost of maintenance, which is undoubtedly greater in the electric outfit. The care necessary for operation and the space occupied are also often important.

A New Era in the Science of Nutrition

How Two Masters in the Art of Experimentation Are Bringing This About

By R. L. Kahn, M.S.

ABOUT four years ago, Dr. Thomas B. Osborne and Prof. Lafayette B. Mendel, began a series of feeding experiments at New Haven, which have had the high distinction of being epoch making from the very beginning. They have been epoch making because chemical analysis, physical measurements and mathematical precision underlay their procedure. These experiments are still being continued and the scientific world waits and wonders what these investigators will unearth next.

It is nearly 30 years since Dr. Thomas B. Osborne was appointed Research Chemist at the Connecticut Agricultural Experiment Station. His many investigations in the chemistry of foods during all these years, have given him a name equaled by few in the entire world of science.

Prof. Lafayette B. Mendel, although comparatively young, has occupied the Professor's Chair in Physiological Chemistry at Yale University for over 15 years, during which time he has gained enviable fame as a chemist of animal life. And to-day his laboratory is the Mecca for those students whose aim is to solve, by chemical means, some of the mysteries of animal life.

These investigators, with the assistance of Miss Edna K. Ferry, Dr. Alfred J. Wakeman and a host of chemists of the Connecticut Agricultural Station, made up a gigantic scientific-research combination, with the modest aim to clear new ground and extend the road of the unexplored territory in the science of nutrition.

MANY-SIDED EXPERIMENTS.

The most important period in the life of an animal is undoubtedly the time of its growth, when its bodily foundation is being laid and the body structure built. These investigators showed us that Nature will not build an animal body if the supply of proper building material be withheld from the animal—if it be improperly fed. The young animal under these conditions need not be underfed; on the contrary, it may consume enormous quantities of improper or inadequate food; nevertheless, it will not become larger and gain in weight—it will not grow—as young animals should and ordinarily do.

The effect of nutrition on growth is, however, only a small measure of their far extended investigations. The rôle bacteria play in digestion, the importance of the inorganic constitutents in our diet, the relative nutritive value of different fats, such as butter and lard, and a number of other problems of practical concern to man, have been investigated by these workers. And when we consider the far reaching importance of these experiments it becomes clear to us why the scientific world has taken such an active interest in them. Efficient and economic feeding is not only of importance to man in his personal pursuit of health and happiness, but to the cattle raiser as well. Science is the greatest waste eliminator we have, and ultimately it will prove to be *the* important factor in reducing the high cost of living.

FORMER VIEWS

It is needless to say that experiments of this nature could not have been undertaken had we still believed that "the food we ate was first converted by the liver into natural spirits, which the blood and inspired air changed into vital spirits and which, on reaching the brain, became animal spirits." Neither would these investigations have been possible had we still thought that the meat (protein) we eat, became body flesh with very little transformation.

It was this latter view which led Justus von Liebig, the great pioneer in physiological chemistry, to suggest that the best food for one who works with his muscles is some other animal's muscle, such as beef. This theory could never make clear how the ox builds up its beef on a purely vegetable diet. We know now, beyond the slightest shred of doubt, that the energy required for muscular work is furnished largely by the carbohydrates (starchy foods) and fats.

Unfortunately the Liebig view is still popularly accepted. Again and again friends advise us to eat meat for strength, forgetting that our domesticated animals which display the most strength, such as the horse and bull, are herbiverous animals and live on a vegetable diet exclusively. This is not an appeal for vegetarianism. Man should eat meat, but let him eat it moderately and not entertain the idea that it supplies him with energy for muscular work.

The erroneous corpuscular theory of light, formulated by Sir Isaac Newton, which kept the world in darkness for several centuries, until the wave theory of light finally conquered, is a similar example in the field of science of a great man's error and its influence.

It is evident that, just as the helpful suggestions of the great exert a goodly influence, in the same way, and to the same degree, do their erroneous views exert their harmful effect.

THE PROTEIN MOLECULE, A HUGE STRUCTURE.

The greatest interest in the study of nutrition attaches itself to the protein molecule; the nitrogenous molecule which goes to build up the various tissues of the animal body. The carbohydrates and fats are our coal foods; they furnish us with the same amount of heat and work energy which they would furnish an inanimate heat engine if burnt in it. But how the protein of a grain of wheat can be transformed into a nerve fiber, a drop of blood or a muscle cell, appeared until recently quite inexplicable. It was known for a long time that the grain of wheat was first broken down in the digestive system, after which the body would utilize the broken down products, to suit its own needs. Further than this, however, nothing was known.

Thanks to the recent laboratory investigations, we now know the chemical nature of the protein molecule better than we ever did before, and we can follow up its life cycle in the animal body with much precision.

The protein molecule, although physically not big enough to be seen with the highest magnification under the microscope, is, nevertheless, chemically a very huge structure. Should we break it up it will yield an enormous number of other molecules. These new molecules the German scientists have christened with an unusually appropriate name. They call them Bausteine (building stones), they being the building stones which go to make up the protein molecule. These building stones are definite chemical substances known as amino acids.

DIFFERENT BUILDINGS WITH SIMILAR BUILDING STONES.

When a protein molecule is allowed to come in contact with acids or digestive fluids, the building stones or amino acids are liberated. These building stones can now serve as the material with which new protein structures, such as liver, brain and muscle protein may be built. This in fact, is what takes place during digestion. The digestive fluids liberate the building stones of the proteins which we eat. These building stones enter the circulation and are distributed to the different tissues of the body, where they serve as the building material with which the body builds new tissues to suit its own needs.

We can now understand how the lion in the jungle, the cow in the stall or the bird in the nest, can build up tissues which are so similar on foods so entirely different. The mystery was solved when the laboratory student subjected a large variety of foods to chemical analysis, and found to his great surprise that the building stones of the various proteins found in these foods were essentially the same.

Just as we have in any city a large variety of structures built with similar materials, we have in nature a large variety of proteins built with similar amino acids. Some structures in our city, embodying more building material, are larger than others; others, again, containing different proportions of certain building stones may vary in form or style. Similarly, some of our proteins lack amino acids, like gliadin of wheat and zein of maize, and are therefore smaller—or to use a laboratory phraseology—are incomplete proteins. Other proteins again, are believed to contain different proportions of certain building stones. Thus, for instance, albumin of egg and globulin of meat are two complete proteins; i. e., as far as is known, they do not lack any amino acids, still they possess different chemical properties. It is extremely probable, therefore, that these two proteins contain varying proportions of the same building stones.

The blood of the lion, cow, bird or any other animal, knows not whether the source of the building stones which come to it be a grain of wheat or a bit of flesh. This is not its business. It is the business of the animal to obtain food, that of the digestive system to convert this food into energy-yielding and tissue-building material, and it is the blood's duty to receive the daily supply of this new material, particularly the tissue-building material, or amino acids, and distribute it to liver, muscles and other organs of the animal body where it may be utilized to rebuild the cells which are being broken down in the daily wear and tear.

A VISIT TO THE LABORATORY.

Let us now spend a few minutes in the laboratory where the experiments with which we are most concerned are being carried on. We are all sufficiently advanced in the science of nutrition to understand fully the work of our investigators.

Here we are in a large and dignified brick building on Huntington Street, New Haven. It is the newest building of the Connecticut Agricultural Experiment Station. We will enter to the right the spacious room on the main floor and watch the chemists at work. Practically all are busily engaged isolating proteins from various food stuffs. We see one adding an acid solution carefully to a 10-gallon jar containing milk. We can see the flocculent precipitate of casein being formed as he adds the acid. He is separating the casein from the milk. Another is isolating edestin from hempseed. A third is re-purifying the glutenin he obtained from wheat, and so down the line. Every one seems to realize the importance of his work, for these isolated proteins are to be used in the feeding experiments of Osborne and Mendel.

In another room we see several hundred cages, each about the size of an ordinary bird cage. In each of these cages one or more white rats are slumbering. These animals sleep during the day and are active at night.

The white rat serves as the experimental animal because of the relative ease with which it can be looked after, and also because the life cycle of this animal and its relation to man has in recent years been carefully studied by Prof. Donaldson at the Wistar Institute.

The duration of life of the white rat is three years. For 20 days after birth it will depend upon the mother for sustenance. It is sexually mature at the age of 60 days, and its entire growth period is completed when it is 280 days old. The first year of the rat's life corresponds to the first 30 years of human life, and, according to Prof. Donaldson, the 3-year-old rat is very old—comparable to the 90-year-old man.

MAINTENANCE AND GROWTH.

To begin with, the diet of these animals consisted of starch, lard and inorganic salts to which was added some isolated protein. Soon our investigators established the fact that there is a difference between the requirements of a mature animal and that of a growing animal. The adult animal needs protein material with which to repair the daily wear and tear of its body; the growing animal needs protein material with which to build up its body. They found again and again that diets which were sufficient to maintain an adult animal in good health were not sufficient for a young animal to grow on.

This, in reality, is what we would expect. You cannot often build a machine with the materials with which you can repair it; and the food which can adequately repair the animal machine may not be sufficient to enable the animal to grow and build up its body. Nature set down more rigid food requirements for the young animals than for the mature ones, to make sure that the bodily foundation which the former build during their period of growth be of solid and strong material so that it will withstand weathering later in life.

Growth is, indeed, a very mysterious phenomenon in the life of an animal. The growth-impulse, or "*Wachstumstrieb*" as the German physiologists call it, is inherent in all animals. It appears to be a function of the young animal cell. Nutrition, no matter how rich, can neither hasten nor prolong growth; if inadequate, however, it will interefere with the growth of an animal.

UNDERFEEDING AND IMPROPER FEEDING.

There appears, also, to be an important difference between underfeeding and improper feeding. If you underfeed an animal, that is, if what you give it is nourishing food but of insufficient quantity, you will not interfere with its ability to grow. Its growth, however, will be at the expense of its own tissues. The bones will enlarge, but the muscles and other tissues, not receiving sufficient nourishment, will waste away.

Should an animal be improperly fed, as is the case when you feed it with an isolated protein which lacks building stones, growth itself will be interfered with. Under these conditions, no matter how large the quantity of food the animal may consume, it will not grow.

Take for instance Rat 240. Its diet consisted of starch, lard, inorganic salts and gliadin, one of the proteins of wheat which is known to lack several building stones. At the age of 140 days it weighed only 55 grams, when it should have weighed about 150 grams. Now this animal did not suffer from underfeeding; it ate well and its energy requirements were fully supplied, nevertheless, it was unable to grow. It is fair to assume, therefore, that the lack of some building stones in its food prevented this animal from building up its body.

THE FRANCHISE TO MANUFACTURE BUILDING STONES.

It has been known for a long time that an animal cannot live without certain specific food stuffs. An animal needs to have some carbohydrates with which to supply its body with heat and work-energy. It needs minerals with which to build its skeleton, and other inorganic salts to maintain its body fluids in proper chemical equilibrium. And, finally, it needs protein, or more

specifically, building stones, with which to build the animal machine.

Withhold protein, carbohydrates or inorganic salts from the diet of an animal and the animal cannot live. However, feed an animal with a protein which lacks several building stones and it will live, but will not be able to grow.

This is very remarkable. Nature starts out an animal in its struggle for existence with the most abundant equipments for life. All its organs contain far more material than it actually needs. More than half of its liver and pancreas can be removed with impunity. Remove a lung or a kidney, or let an animal lose more than half of its blood, and still the animal will have its health. Nature provided the animal with every conceivable means to continue its life in the midst of adversities. However, the franchise to manufacture building stones nature granted almost exclusively to the plant kingdom. And if you withhold building stones from an animal's diet the workers of the animal machine will lay down their tools. Work will stop. The animal structure will not be built.

Supply plants with the raw chemical elements, such as carbon, hydrogen, nitrogen and so on, and sunlight, and the most complex structures will be built by them. Animals can not do this. The digestive systems of animals can only break down the structures built up by plants, liberate the building stones and utilize them to build up the animal body.

WHEN NATURE OVERRULES HER OWN LAWS.

We always think of Nature as doing her work in an orderly and well-regulated manner. It is difficult to conceive of Mother Nature hurrying about her work. In guiding the building of an animal body nothing can lead Nature off her path, providing, of course, that the animal receive the proper building material. A rich diet will not bribe her; the animal may store up some fat, but its growth it cannot hasten.

If, however, an animal which is stunted for a given time, due to improper food, begins to receive a diet which is adequate, it will immediately begin to gain in weight and grow by leaps and bounds. Nature then will overrule her own laws of growth in order to help the animal gain what it had lost.

Rat 208, for instance, received a diet similar to that received by Rat 240, gliadin of wheat serving as the only protein. The animal was stunted for 40 days; then a part of the gliadin was replaced by casein of milk. This new protein supplied the building stones which gliadin lacked; the animal began to grow with unusual rapidity, and quickly gained what it had lost during the period it was stunted.

It is evident that Nature provided the cells of young animals with a far greater growing capacity than that which they normally make use of during their period of growth. Here we have still another of Nature's provisions for the well being of animals.

THE INORGANIC SALTS.

No phase in the diet of an animal has been overlooked as much as the rôle of the inorganic salts in it. They neither supply us with heat and work-energy (with the exception of calcium which goes to build bone) nor serve as material with which the body builds its tissues. Nevertheless, life is impossible without these salts. To remove the inorganic salts from a diet is more fatal to an animal than starving it. An animal which is able to live 60 days without food will not live half as long if its food is free from inorganic salts.

The inorganic salts seem to regulate the concentration of the fluids of the body. We know from experience to what extent our intestines become flushed when taking a saline cathartic. Fluids from all parts of the body rush to the intestine in order to dilute the concentrated salts and bring it in equilibrium with the other fluids of the body.

The inorganic salts are as important to the life of an animal as cement to the brick structure. Remove the cement and the structure can not stand. Remove the inorganic salts from our diet and life is impossible.

Mixed foods ordinarily contain sufficient inorganic salts to supply the needs of the animal body. The adding of table salt to our diets is, in most cases, the result of habit and not, as is the opinion of some, because the body actually requires the additional salt.

The white rats, being supplied with chemically isolated food materials, had to receive definite quantities of inorganic salts in their diets. After overcoming a number of difficulties our investigators furnished the inorganic salt requirements to these animals in a very novel fashion. They removed, by chemical processes the proteins carbohydrates and fats of milk, and left in it the inorganic salts. This fluid contained inorganic salts in the proportion in which Nature provided, and by adding it to the diet of these animals, it served the purpose excellently.

THE RÔLE OF BACTERIA IN NUTRITION.

The fear of germs has been so exaggerated in recent years that it is causing far more harm than the very bacteria which are most pathogenic. Indeed, the lowered resistance to disease which fear is sure to bring on will often make one susceptible to the bacterial diseases which he fears most. Of the countless bacteria which fill the air, water and soil, those that are known to bring on disease can be counted on our fingers, while the rest are busily engaged in enriching our soil, purifying our water, flavoring our foods and, in many other helpful fields of pursuit, being possessed with the single aim of making animal life possible.

We have known for some time that bacteria play an important part in the processes of digestion without, however, knowing definitely what this part is. Osborne and Mendel have shown specifically, in the course of their experiments, that bacteria exert a beneficial influence in the alimentary tract of animals.

The diet which they gave the rats, being chemically pure, was almost free from bacteria, and the animals under these conditions would *often show signs of ill health*. They thereupon decided to supply their animals with the proper bacterial flora. Their scheme was to add to the diet of their animals small quantities of excreta obtained from rats which were fed on regular mixed diets. Their rats thus obtaining intestinal bacteria of normal animals, showed marked improvement in practically every case.

To remove the possibility that there were other ingredients in the excreta, besides bacteria which brought about the beneficial effects, they killed the bacteria by sterilizing this material and fed it to the animals as they did before. The result was that the helpful effects were not in evidence.

That bacteria are helpful factors in digestion ought to be impressed very strongly, if for no other reason than to help allay the prevailing fear of these little bodies. The pathogenic germs can do us no harm unless they are given an opportunity to grow in our tissues, and this we virtually permit them to do whenever we lower our resistance by over-worry, fear, etc. In health, however, our bodies are sufficiently equipped to overcome the disease germs.

THE FATS.

We have spoken before of the importance of proteins, carbohydrates and inorganic salts in the foods of animals, to the extent that the removal of any of these from an animal's diet would cause the death of that animal. Whether or not fat is essential to the life of an animal has also been studied by these investigators.

They fed a number of animals with diets which were almost free from fats, and found that such diets did not interfere with the health of the animals. It would appear, therefore, that animals can grow and maintain good health for a time on a diet which is nearly free from fat.

This, it is readily seen, is only of scientific importance. In actual life it would not be advisable to eliminate fats from our diets on account of their relative cheapness and high heat value.

Osborne and Mendel have very recently carried out a series of experiments which have a more practical bearing. They tested the relative nutritive value of butter and lard. Butter, according to their experiments, is far more nourishing than lard. Animals which appeared weak and ill when getting lard in their diet showed marked improvement when butter was substituted.

At the present time these scientists are concerned in the study of the relative nutritive value of the various vegetable fats, such as olive oil, linseed oil, etc.

The experiments of Osborne and Mendel are known and discussed in every biological laboratory in this country and abroad. They have caused old theories to fall, and new theories to form. The science of nutrition is undergoing a period of reformation, and we feel not a little proud that two American scientists are among its reformers.

Recent Developments in X-Ray Tubes*

PROF. W. C. RÖNTGEN of Wurzburg, Bavaria, suspected that when a current of electricity passed through a glass tube containing a gas at very low pressure, invisible light waves were given off. The idea occurred to him that such rays might affect a flourescent screen in much the same manner as did ultra-violet rays. In order to cut out the visible light from his vacuum tube he wrapped it in heavy black paper. Upon operating the tube to make certain that the covering was completely light-tight, he noticed to his surprise that the flourescent screen which he had left on the table three or four meters away glowed brightly.

Röntgen investigated the properties of the X-rays with characteristic German thoroughness. By 1897 he had amassed such a volume of information about X-rays that nearly every essential piece of research on their properties up to 1908 can be found in its more elementary form in his three original memoirs.

Röntgen's original tube of 1895 was, judged by modern standards, a pretty crude affair. The cathode was flat and emitted a diffused bundle of cathode rays which, upon hitting the glass at the far end of the tube, produced X-rays. In 1896 Campbell-Swinton added a platinum target upon which the cathode stream hit. This increased the penetrating ability of the rays obtained. In the same year Jackson made the cathode concave so as to focus the cathode stream upon a small area of the target. By giving more nearly a point source of X-rays this increased the clearness of radiographs for diagnostic purposes. The X-ray tube was soon changed in form, but not in principle. A regulator was added by which the pressure inside the tube could be increased at will, and various means were tried for removing heat from the focal spot of the target.

Meanwhile in 1912, Dr. Coolidge discovered the process of making ductile tungsten such as is used in the filaments of mazda lamps. Shortly after this discovery he became interested in perfecting a wrought tungsten target for X-ray tubes. During this work it became necessary to operate the tubes up to the limit of their capacity in order to find out how much abuse the tungsten targets would stand. During the course of this work he found that the ordinary aluminium cathode could be melted if sufficiently high currents were sent through the tube. He tried to remedy this by substituting a cathode made of tungsten whose melting point is very high. But such tubes were found to be very unstable. When current was sent through such a tube, the vacuum increased rapidly until finally no current would pass through the tube until gas had been liberated from the vacuum regulator. From a practical standpoint such a tube was hopelessly unsatisfactory. Finally it was found that if the process of operating the tube and immediately reducing the vacuum were repeated rapidly enough, the cathode became hot enough to glow, and that after this the tube would operate for several minutes at a time without it being necessary to let in fresh gas from the regulator. This suggested the idea of a cathode heated by some external means.

Richardson, and others in 1902, had shown that electrons could be obtained by merely heating the cathode, but had not been able to obtain constant results. Dr. Langmuir of the Research Laboratory of the General Electric Company, had shown that the rate of emission of electrons from a hot tungsten cathode in a very high vacuum depended only upon the temperature.

If we heat a tungsten filament, electrons are given off and soon a condition of saturation occurs around the filament. If the filament is made the cathode of a low-potential circuit, a small current passes. If the voltage is increased, a larger current passes. Finally a voltage is reached which sweeps away every electron as fast as it emerges from the hot tungsten. For all voltages above this, the current is constant, and is independent of the voltage. Thus we have a resistance as far removed from the ordinary Ohm's law resistance as possible. This is not because the conduction is carried on in any different way, but because the number of available electrons is limited. (The reason that Ohm's law holds in conduction through wires is that the supply of available electrons in the wire is practically unlimited.)

As a source of electrons in his tube, Dr. Coolidge made use of a small spiral of tungsten wire heated white hot from a storage battery in exactly the same way in which electric automobile lights are operated. This spiral is the cathode and a block of gas-free tungsten is the anode. The rate at which electrons are given off from the spiral depends upon its temperature, which is under the immediate control of the person operating the tube. The voltage across the tube is also controllable at will. As the voltage employed in ordinary X-ray work is much greater than is necessary to snatch all the electrons across from cathode to anode as fast as they are evaporated from the filament, even at the highest currents now in use in X-ray work, the voltage and current passing through the Coolidge tube are totally independent. Both may be adjusted to any desired value with any degree of precision desired, and at any such adjustment the X-ray performance of the tube can be duplicated time after time.

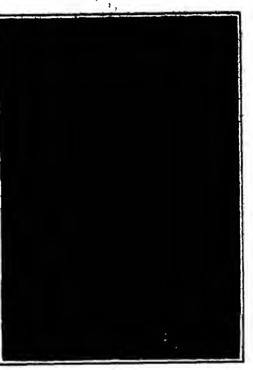
* Abstract of an address by Dr. W. D. Coolidge before the Edison Club, at Schenectady, and reported in the *General Electric Review*.

A Novel Engineering Expedient

OUT in Honolulu it became necessary recently to lower a large and heavy steel tank into a deep pit where there was very little space beyond the dimensions of the tank, so that the workmen had no room for ordinary blocking of the size required. The difficulty was met by building up a blocking of ice, and subsequently melting it out by steam.

Stamping makers marks on blades.

Tempering knife blades.



Turning handles.

Making the ferrules.

Stamping ferrules by a drop press.

Forming blades on a punch press.

Drawing blades under power hammers.

The Cutlery Works of Thiers

Manufactures of the Old French Town Where Knives Have Been Made for Centuries

By Jacques Boyer

WITH its cutlery shops scattered along the water's brink on the right bank of the turbulent Durolles, Thiers is one of the most picturesque villages of France. Built one after the other at the bottom of the valley, these curious workshops, known throughout the district as "wheels," contain each some 6 to 12 grindstones, and in the course of a year thousands of knife-blades are sharpened in them. The workman, it should be said, labors as he pleases in these shops, as he is merely a tenant of the place he occupies in return for a rent of 80 to 100 francs a year to the owner of the "wheel." Thus, he preserves his liberty and comes when he sees fit to perform his severe task.

The operation of knife-grinding (in a primitive and painful but original fashion) is still carried out at Thiers. The grindstones revolve on a horizontal axle set a little above the river and the lower part of the stone dips into the water, which thus acts at the same time as a lubricator and cooler. The Durolle furnishes all the motive power for the entire workshops in which grinders are seen lying on their stomachs on planks. The plank, slightly inclined toward the workman, rests on a scaffolding, and its hardness is softened by a cushion or sheepskin. Keeping the head and shoulders up in the air, each man holds in his hands below the plank the piece of steel cut out by a punch from which he is to make a knife-blade by pressing it against the circumference of the grindstone. When it is necessary for the grinder to exercise considerable pressure, either to make the point or to thin a part where the metal is too thick, he raises himself slightly and presses the blade against the grindstone with all the weight of his body. On account, however, of the humidity prevalent in the "wheels," the poor fellow stretched at full length is easily benumbed and ends by being very rheumatic.

To avoid these ailments, therefore, as much as possible and to keep themselves from getting cold, the grinders use little dogs as "furnaces."

When ready to begin work each one of them whistles. Immediately a faithful little dog, trained to this task, comes to roll himself up on the crossed legs of the grinder. The intelligent animal covers its master's legs as much as possible, and at times stretches itself upon the grinder's back; in this way it communicates a gentle heat to him without which the lack of movement would cause the master to become chilled in a short time. The poor animals seldom live to grow old. After having filled for several years the office of a living "footstove" they become crippled, are killed to save them from useless suffering, and are replaced by another spaniel or nameless mongrel.

As early as the thirteenth century the "*costeliers*" (old French for cutlers) were carrying on their work in the old Auvergnat town of Thiers, but the first authentic documents discovered by the archeologist Gustave Saint-Joanny only go back to the end of the fifteenth century. These papers are, first, a pardon granted in the month of October, 1460, by King Charles VII to a cutler of Thiers, Jehan d'Urson, who had compromised himself by making the molds used by a Parisian goldsmith named Faurel to turn out base money at the chateau of Saint-Cirques near Issoire. Then, a fragment of the land-book of the barony of Thiers, dated 1474, shows that a fourth of the population was at that time engaged in the cutlery trade. The industrial activity of Thiers began about this epoch, as did also that of Sheffield, and the town developed into an important cutlery center; this importance continued until the eighteenth century, when the industry began to decline. However, the knife popularly called *eustache* was still manufactured in Auvergne and excited the admiration of Fen at the exposition of [illegible]. The

Museum of the Louvre has a genuine example of this knife with a blade closing without a spring; on the one side of its wooden handle is the word "veritable" (genuine) and on the other "Eustache Dubois," name of its maker in Thiers. The expression *eustache du bois* (wooden eustache), generally used in France to designate this kind of knife, is therefore incorrect.

During the nineteenth century the manufacture of knives steadily improved in France. From 1848 in particular the cutlers of Châtellerault began to use machinery for the mechanical manufacture of the handles; then came forging and filing machinery, which improvements were adopted long afterwards by the factories at Nogent and Thiers.

At the present day two classes of knives are made—knives that do not close, as table-knives, and spring-knives, as pocket-knives.

This much being clear, let us take up the processes in the manufacture of knives which do not close, and begin with "the blade of the eustache," the blade which it is necessary in succession to forge, harden, grind in order to obtain the cutting edge, and finally to polish.

Steel rods of good quality having been selected, they are divided into equal lengths, which are drawn out at one end to form the blade and at the other to form the tang that is fitted into the handle of horn or wood. The drawing is done by a small trip hammer which strikes 300 to 400 blows a minute. Then the bolster or shoulder is made by pressing with a fly-press the part of the steel that remains between the blade and the tang. A cutting machine then gives the blade its final form, and various reheatings or cold hammerings restore to the steel its original physical qualities. As a fact, in the course of stamping the crushed metal loses its homogeneity, so that, in order to make a good knife, it is necessary to use special steels from which the blades are forged by hand in the old way, or by the aid of suitable machinery to multiply the blows of the hammer as a blacksmith does. These methods, though, demand a large expenditure of time and energy, and it is, therefore, better to use a rolling process, by which, after a single heating, the workman in drawing the metal causes a regular displacement of the mass with a minimum of effort and without altering the internal structure of the metal. The principle of the various machines is that two cylinders each having a concave die of half the thickness of a knife give to the blade its general form. The workman inserts the steel rod, cut to the desired length and heated red hot. It comes out on the other side transformed into a blade. Unfortunately these machines are expensive; new cylinders are frequently needed and the price of renewal is high, while, in addition, they are suited only to a single fixed model. Consequently, a new rolling machine has been lately invented, consisting of one small unstamped cylinder and a plate carrying the matrices of the different blades and traveling on a carriage formed as a slide bar. The movement of the carriage is produced by means of a screw or a rack bar, or a connecting rod and eccentric, while the rotation of the cylinder is caused solely by the adherence of the objects to be rolled. The cylinder is fixed on an adjustable shaft which can be regulated according to the thickness desired. The steel cylinder lasts indefinitely, and it suffices to true it each week with an emery wheel. As to the matrices, which vary with each model, they bear five rehardenings easily, and can strike off 500,000 blades before being worn out.

Whether the blade has been made by hand or by rolling machinery its surface is rough and the contours inexact. It is, therefore, necessary to go on to the smoothing down which was formerly done with a file, but is to-day executed by special cutters which give it the final form. On leaving these machines the blades receive a preliminary grinding in order to equalize the thickness of the cutting side. This whitening reduces the later work of the grinder after the blade is hardened. It also facilitates the stamping of the mark which is made by placing the tool engraved in relief on the blade, lying flat on an anvil, and striking a heavy blow with a hammer, which stamps the mark on the blade.

Fine blades are still hardened as in the eighteenth century. They are first heated with charcoal to a clear red and then they are quenched in water. After this they are again slightly heated to temper the steel and to give it elasticity, and when the metal becomes straw-colored or blue, according to its quality, the tempering is checked by quenching the blades again in cold water. The blades of moderate priced articles are hardened in the following manner. A fireclay crucible filled with lead is set in an ordinary furnace, and as soon as the metal boils the workman seizes in succession with pincers each blade to be hardened by the tang and plunges it up to the bolster into the crucible. As the blade is thin it quickly acquires the temperature of the lead, the workman draws it out and immediately plunges it into a pot of colza oil, which may be seen to the right in one of the illustrations. An iron grating on the top of the pot stops the blades by their projecting parts and the number of its interstices for blades is just sufficient to keep the temperature of the oil bath at the right point. The hardening has much influence on the value of the knife, for it gives resistance, hardness, and elasticity to the steel. As, however, hardening rarely gives these three qualities at the same moment to steel, it is necessary to repeat the process several times and the skill of the workman plays a large part in the final result.

During the tempering the metal passes successively through characteristic shades of fire colors. To obtain a very tough steel it is tempered to a deep blue; if it is to be more hard than tenacious, to a straw color, etc. For example, knives with strong blades are heated to a copper red, bistourys, and penknives to an orange yellow, razors to straw color. Finally, certain articles, as lancets, demand special care and need to show several shades at the same time when in the fire. Thus a fine knife will show in the tempering the color of water, violet, and copper red in succession from the back to the cutting side.

Next comes the grinding, the beginning of the sharpening which gives the cutting edge to the blade. As was said in the early part of this article, it is done by grindstones generally made of Vosges sandstone. The stones are 1.33 meters in diameter and 0.15 meter thick and turn at a moderate velocity in a trough constantly filled with water. After it has sharpened 600 to 700 dozen blades the grindstone is worn out, being reduced in diameter to 0.66 meter.

The sharpening, which follows the grinding, gives the edge to the cutting side, and is done by hand on whetstones of different kinds according to whether the knives are large (quartzose sandstone), or the blades fine (greenish close grained schist).

As has been already said, grinding is a fatiguing operation for the workman, as their task is carried out in a humid atmosphere full of metallic dust. At Châtellerault the grinder stands. In whatever way it is done the work is laborious. Efforts have been made to find mechanical methods of doing this work, but no grinding machine that has been devised up to now appears to have solved this difficult technical problem. One patented some five or six years ago seems, however, to be an ingenious device, although up to the present not largely in use. This machine requires only two workmen, and when once regulated sharpens 200 to 300 pieces per hour. After it has sharpened 100,000 blades the grindstone of the machine has to be replaced.

Be that as it may, it is necessary to smooth and polish the blades in order to give them fineness and metallic luster. This work is usually done on wooden wheels covered with felt or with pieces of buffing leather coated with emery, and driven at an average speed of 2,000 to 2,500 rotations per minute. They are partly inclosed by a horse which serves as a seat for the workman and protects him from the flying dirt, and they are able to execute several kinds of operations. One man first polishes the bolster, another the back of the blade, a third the blade, and at this point the polishing stops for common cutlery. For more carefully made articles the work is carried farther with polishing wheels or laps covered with leather and coated with tin putty or crocus. Sometimes certain manufacturers at Châtellerault send the blades to another special polishing wheel coated with a mixture of wax and flour emery. Lastly, cutlery of complicated form is polished by wheels equipped with brushes soaked in a mixture of emery, tin putty, and crocus.

The blade of our knife being now completed and brilliantly polished, let us examine the manufacture of the handles of ebony, or other rare woods, bone, horn, and ivory.

The work commences by cutting up the crude material with a circular saw into pieces of the desired length and thickness, then into roughly shaped handles, which are trimmed by planing. Each handle is then put successively into a tool which presents its end to a special cutter fixed in a rapidly rotating shaft. After this the handle is set on a planing machine with a cutter appropriate in form to the shape of the future knife. Then an open guide presents the four sides successively to a tool which, revolving below the handle at a speed of 2,500 revolutions per minute, ornaments the sides with more or less artistic chasing. The place for the ferrule is made on a lathe, and the piercing of the hole to receive the tang of the blade is also thus done. Finally, the handle is polished with various kinds of wheels or laps coated with a mixture of pumice and oil. Pearl handles, though, are dressed by hand after they are sawn out.

We have now the two essential parts of the knife: the blade and the handle. All that is now lacking is a ferrule of German silver or silver to unite them. The hand ferrules of common knives are generally made from strips of German silver rolled and grooved. The strips are divided into pieces of the desired length, and the two ends are brought together and soldered.

For finer cutlery the ferrules are stamped out as follows: The German silver at a thickness of 2½ tenths of a millimeter is cut into strips and pieces suitable to make half a ferrule. Each of these pieces is then put under drop-hammer, the matrix of which imprints the desired ornamentation on it, and then a cutter removes the unnecessary metal. The ferrule halves are reheated and prepared for the soldering by passing the two faces flatwise against a Lombardy stone in order to smooth them. The workman then unites them by twos with a very fine wire and fills the joints with solder mixed with powdered borax. He then places the ferrules on a long wire spit which he sets on a grooved board arranged to receive three or four dozen spits and places them in a furnace. When one side of the ferrules is welded, then the other is done, after which they are cleaned off with nitric acid and vitriol. Lastly, the seam is smoothed down with a small file and the ferrule is polished with a brush.

The making of silver ferrules does not differ greatly from the manufacture of German silver ones. It is now necessary to assemble the three parts (blade, handle, and ferrule), the manufacture of which has just been described.

First, the fitter puts the ferrule on the handle, then, according to the particular case, he enlarges the opening in the handle or reduces the tang of the blade to make sure that the bolster has a true bearing. Another workman then seizes the trued knife, draws the blade from the handle and puts the tang of the blade to heat on a charcoal brasier. While this is heating he fills the hole in the handle with a cement made of resin and powdered brick. He then forces the tang, which is red hot, into the handle. The cement melts, and after the work has cooled a third workman rubs the ferrule clean and sends the knife to the polisher, who puts the final polish on the handle. The knife now goes to the filer, who removes the over-thin part of the cutting edge, which by doubling over, would prevent the edge from cutting. This last operation, which is at least the thirty-eighth phase of the manufacture for ordinary articles, is done on a Normandy stone, and is repeated on a Lorraine stone with a finer grain.

The manufacture of spring knives closely resembles in its main outlines that of table knives except in the making of the handle. The metal pieces or scales which form the handle are made by a punching machine and are finished by filing. The assembling consists in uniting these scales and the spring by two rivets fastened in tight, and the blade is introduced between the two scales. The head of the blade is fastened by means of a rivet, to which a little play is allowed. As the scales are generally covered by plates of other material the latter are set on before the assembling.

It should be said in closing that though knives are an object of primary necessity they are made only in a few centers. Thiers, Nogent (Department of Haute-Marne), Châtellerault and Langres in France, Sheffield in England, and Solingen in Germany, flood with their products all the markets of the world, notwithstanding the enormous customs duties, sometimes over 50 per cent of the value of the objects as in the United States, and rising even to 975 francs per 100 kilogrammes for fine cutlery in Russia. Up to now the English and Germans have been much more active than the French and have secured, to the damage of the latter, the larger part of the business throughout the world. Before the present war Solingen with its suburbs formed a town of over 150,000 inhabitants engaged almost solely in the cutlery trade. Its annual output was valued at more than fifty million francs, of which it exported to the value of thirty million francs. It had the audacity to send its knives to Thiers, whence they returned bearing the justly renowned Auvergnat stamp, so as to compete more easily with French articles. It is to be hoped that the French will now be wise enough to protect themselves against such proceedings.

Sheffield, which turns out an article of good quality, manufactures annually, for its part, cutlery to the value of 40 million francs, of which it exports to the value of twenty million francs. The factories of Thiers and Châtellerault, therefore, ought to adopt modern equipment in order to battle with success against such formidable rivals.

Old English Seals

An examination of the old wax seals on documents in the British Public Record Office show that those dating between the thirteenth and eighteenth centuries have a composition almost exactly like modern sealing wax. A specimen of the Great Seal of 1580 was found to be composed of pure beeswax; while two seals on documents bearing dates 1399 and 1423 were of bees wax that had characteristics more nearly like the Indian than European article.

The Reaction of the Planets Upon the Sun—I*

Influence of the Earth and a Study of Sun Spots

By P. Puiseux,[1] Member of the Institute, Astronomer at the Paris Observatory

The popular preconception that the earth, with the sun rotating about it, was the center of the universe, was overcome only through the persistent efforts of astronomers and physicists. We will not here review these memorable discussions, but will note merely the result. Everyone capable of connected and geometrical reasoning will become convinced that the position of the earth, face to face with the sun, is that of a humble satellite, and that our globe, forced to escort our daytime star in its mysterious course through space, receives from this star its law of annual movement and at the same time its indispensable ration of heat and light.

Going from one extreme to another, the sun was believed to be independent of the relatively minute planets which it carries along with itself. It seemed that a fictitious observer, placed at its center or on its surface, would have no occasion to suspect the existence of other celestial bodies. Further protected against any perceptible action from the stars by their immense distance, the sun must lavish its splendor, with no pay in return, and follow unperturbed its undeviated path through space.

THE INFLUENCE OF THE PLANETS ON THE MOTION OF THE SUN.

This conclusion was in some respects too radical. An account of this matter could be rendered only when the penetrating genius of Newton showed that the curved trajectory of a projectile, the revolution of the moon about the earth, and the revolution of the earth around the sun were three manifestations of the same law. This law holds everywhere. Further, it is not a special privilege of the center of any system. The bond exists, real though slight, between any two particles whatever. The sun, as well as the humblest planet, because of this bond, must undergo periodic variations in its speed as well as in its shape.

Have we to-day at our disposal sufficient delicate means of observations to detect these changes? In Newton's time such means were probably lacking. The caprices of our atmosphere furnished a ready explanation of the apparent fluctuations in solar radiation. The spots had been observed on the sun's disk, sometimes few, sometimes many, but no law had been assigned to them. Further, the traditional fixity of the constellations led to the belief that the sun maintained a complete immobility with reference to the stars.

But the problem plainly stated aroused new attempts at its unravelling. Bradley, a fellow countryman and a disciple of Newton, showed that much greater precision could be obtained in the measures of the angular distances of the stars than had before been gained. Less than a century later, W. Herschel could affirm that the constellations do alter their form, and the best determination of these changes may be explained by attributing to the solar system a regular rectilinear motion. The ambition of astronomers, increasing with success, tries to-day to show that this movement is not rigorously uniform, and even though shielded from the action of the stars, pays tribute to the universal attraction in periodic oscillations.

It is pretty safe to predict what will be the most marked of these oscillations. It is not the center of the sun itself which possesses the uniform rectilinear motion, but the center of gravity of the system formed by the sun and all the planets. The oscillation would be small if only the earth need be considered. There is, however, a giant planet, Jupiter, whose mass exceeds that of all of the other planets taken together and is nearly 1/1,000 that of the sun. Describing its orbit at the rate of 12 kilometers per second, Jupiter forces the sun to rotate about an imaginary center with a velocity a thousand times less. This is apparently a very small amount, but not at all negligible with respect to the velocity of translation of the solar system, which is 20 kilometers per second. Consequently, the speed of the solar system toward a point in the constellation Hercules is sometimes accelerated, sometimes slowed, by one part in one thousand in an interval of 6 years.

Very few of the stars are near enough to us for the parallactic displacement relative to the more distant stars and due to this motion of the sun to be appreciable in 6 years. Consequently, to measure 1/1,000 part of this displacement is beyond the resources of precise astronomy. We may be pretty sure, though, that some day we will thus obtain, at the same time with a measure of the mass of Jupiter, a satisfactory new confirmation of the principle of the universal attraction of gravitation.

Meanwhile help comes in another way. What the micrometer for a long time will probably be unable to give, the spectroscope is always furnishing. Although the variation of 30 meters per second, which we wish to detect in the motion of the sun, requires years to change sensibly the apparent position of a star, it takes only a moment to alter the quality of its light. Whatever the distance, the light waves will come to us sometimes more frequently, sometimes less; their path through a prism will consequently be found altered and the fine metallic lines of the spectrum recorded by a photograph will be displaced relatively to those of a stationary source, such as an electric spark used for comparison.

The earliest happy applications of this principle were due to Huggins and to Vogel. It was used to separate numerous double stars composed of pairs of suns so close to each other and so distant from us that each pair appeared as a single star. But the brightness of each was sufficient to record a spectrum and the relative velocities were sufficiently variable so that two spectrum lines of the same chemical origin separated periodically. Subsequently another class, yet greater in number, was found in which the spectrum lines were not doubled, but showed a periodic oscillation. In this case we may suppose that one of the two stars, while not bright enough to register its spectrum, is yet heavy enough to sway its associate. The period is usually several weeks or days. The displacements of the lines correspond to velocities of the same order as those of the planets, from 10 to 100 kilometers per second. Because of the extreme accuracy and care in the use of spectroscopes, certain astronomers can now measure velocities to a fraction of a kilometer.

The time will come when pairs like the sun and Jupiter can be detected, however distant they may be, provided only that the principal star is bright enough to record its spectrum. Campbell, who is the leader in this class of research, estimates that on the average one star in three will be found spectroscopically double. It is very probable that even more stars are double since we can see no reason why a planet like Jupiter should be exceptional. We may predict that all stellar spectra will be found thus variable even after correcting for the orbital movement of the earth. We may then gather photographic evidence of the existence of planets about the stars as well as the periodic oscillation of our sun due to Jupiter. The earth, of course, will produce a similar effect only less in amplitude and period. But who would dare to put a limit to the skill of our opticians or the patience of our astronomers in a path so definitely marked out?

THE PLANETS AS THE CAUSE OF THE SOLAR CYCLE.

To find that we disturb the sun is of course something to elate us. We feel perhaps a more tangible satisfaction if we can find that we cause changes in the aspect of its surface, disturbances visible by direct and not indirect evidence in the field of the microscope.

We will now consider a deforming action dependent also on Newton's law but of a differential nature and consequently proportional to the inverse cube instead of the inverse square of the distance. This difference helps to compensate for the inferiority of the mass of the earth with reference to the greater planets and gives it a chance for an honorable rank in this contest.

We have under our eye an encouraging phenomenon. The attraction at the surface of the earth due to the sun is but a small fraction compared to the weight of a body here, and the yet feebler attraction due to the moon can not lighten a body by 100/1,000 part of its weight. Yet we see the moon exerting this power and indeed with three times more strength than is felt from the sun, in deforming our globe. This action can be detected upon the atmosphere, the oceans, and even the solid crust of the earth. The seas, however, are what render it most evident to our eyes. Under favorable conditions, for instance, in the Bay of Mont St. Michel, on the French coast, we see the sea following faithfully the passage of the moon across the meridian. The sea's level changes at the flood some 20 meters in a few hours, displacing the shoreline several kilometers. The work thus developed, if we could only put it to use economically, would be enough to render useless all our oil wells and all the engines in the world.

We may find that no planet is as favorably situated to trouble the sun as the moon is the earth. But perhaps we should not be so exacting. We see upon the sun no such liquid seas which might be made to extend or contract their domains. The weight there to be conquered is great, 27 times greater than here. Despite that, we see chances that the sun may react as actively, or even more actively, than the earth, under the action of a distant body. We are indeed led by several converging paths of reasoning to think that the surface layers of the sun are to a great depth formed of extremely tenuous mobile matter, little subject to the action of weight and all ready, consequently, to obey the least force.

A first piece of evidence along this line is the development of spots, rents which seem to appear in the luminous veil of the solar surface, reaching in a few days an extent of 10, 20, or 30 thousand kilometers and disappearing with equal rapidity. In the spectrum of these spots there is an increase in the number and intensity of the absorption bands, leading us to think that various metallic molecules of considerable atomic weight are spouted out in torrents, carried along by currents of lighter hydrogen.

More impressive yet is the appearance of protuberances—clouds which develop and remain at heights where they could not be sustained by the dense and refringent atmosphere. Much less bright than the disk, they have a special spectrum and during total eclipses are the principal source of light. We can now photograph them at any time about the edge of the disk by an ingenious method devised in 1868 by Janssen and by Lockyer and since singularly perfected. On many occasions we have been assured by incontestable evidence that protuberances can mount in a few hours in the form of vertical jets, narrow at the base to prodigious heights—50,000 to 100,000 kilometers or even more. Generally, however, before attaining such heights the protuberances expand into sheaves or stratified layers. At times they seem to be the seat of violent explosions, are scattered, and disappear very quickly. The spectroscope shows us that calcium vapor, despite its atomic weight 40 times heavier than that of hydrogen, rises very high in the protuberances. The displacements of the spectrum lines also furnish confirmation of the enormous velocities (100 kilometers or more per second) which the deformations of the contours suggest.

Total eclipses, during which protuberances first attracted attention, are even now the only occasions when we can see another interesting phase of solar activity—the solar corona. Sometimes it appears as a halo somewhat equally distributed around the disk, at other times as gigantic streamers stretching out distances several times the diameter of the sun. The forms of these rays indicate that the matter of which they are composed shows no haste in falling back into the sun. This matter is evidently very sparse and has very little absorptive action on light, for, despite its irregular distribution, it causes no difference in the appearance of the various parts of the disk. Its mobility must be very great since in the interval of two or three years between eclipses its structure completely changes, as our photographs assure us.

Spots, protuberances, and corona are subject to a great variation which takes place regularly about nine times in a century. After a period when the sun's disk appears entirely immaculate, spots re-appear in both hemispheres at latitudes from 20 degrees to 30 degrees, then, always increasing, they invade the equatorial regions, becoming at the maximum 20 times more numerous on the average than in a minimum year. Then, as the decline commences, the numerical predominance, which the Northern Hemisphere at first seemed to show, passes to the Southern Hemisphere. The spots first disappear in the high latitudes and then diminish all over the sun.

The protuberances pass through a similar cycle, except that during the period while their number increases their mean latitude tends to increase in each hemisphere. Toward the epoch of spot maximum, and only then, it is not rare to see great protuberances even near the poles, where spots never appear.

The corona during the same period always undergoes a definite evolution. Toward the epoch of sun-spot minimum the polar rays are fine and vertical like the bristles of a brush. The jets in the middle and mean latitudes are much longer and bent toward the Equator. At the maximum period there is little difference with the latitude. During the transition years the poles and the Equator are almost clear and the rays are developed only in the middle latitudes, giving the whole a rectangular appearance.

The more we reflect upon these facts the less are we led to regard the sun as a monarch, inaccessible, and shut up in a tower of ivory. It, like the earth, may have seasons connected with the revolution of the planets and tides connected with its own rotation. To

*Lecture delivered at the Conservatoire des Arts et Métiers, February 23rd, 1913.

[1] Translated from *Revue Scientifique*, Paris, May 3rd, 1913, in the Annual Report of the Smithsonian Institution.

out at least the more active of these external influences is a legitimate task, even though it is not an easy one.

First, do we find one or several bodies which could be held responsible for a cycle of 11 years? The stars seem to be beyond consideration, since in that period there is no appreciable change in their linear or angular distances.

We could, as did John Herschel, blame one or several swarms of meteors, imagined for the purpose. Describing very eccentric orbits, they might graze the surface of the sun, causing the spots. Suitably choosing their revolution periods, inclinations, eccentricities, and the distribution of the matter in their orbits, we could explain the phenomenon in all its details. We must confess that the permanence of swarms of meteors put every 11 years to such a violent test does not seem probable. There is no doubt that meteors fall into the sun in great numbers. But we have no direct proof that this happens periodically and so as to produce visible effects. Such proof we feel that we must demand for this very supple and convenient hypothesis. As these swarms have not been detected, we must leave them and direct our investigations to the planets.

The most important of these planets brings a coincidence at first sight very seductive. Nearly every 11 years Jupiter, in a determinate sense, crosses the plane of the solar equator; also in every 11 years the numerical predominance of the spots passes from the northern to the southern hemisphere of the sun. The same interval separates the return of Jupiter to its least distance from the sun and the return of the sun-spot numbers to their extreme value.

We must not hurry, though, to sign our victory. It is not an approximate concordance but a precise one which we should demand. The periods in years are 11.86 for the revolution of Jupiter and 11.13 for the sun-spot cycle. For the second period which is less well defined, the incertitude is in the hundredths. For more than a century we have careful records of spot numbers which reappear regularly. Now, in the course of a century the difference of 8 months between the periods brings them from complete coincidence to an absolute discordance. What now remains of our hoped-for proof if the nearest approach of the planet must sometimes condition an increase of spots, sometimes their disappearance?

We may suppose that Jupiter's action, though preponderant, is modified by a somewhat slower disturbing force which increases the interval between successive maxima. But the statistics of the number and extent of the spots, analyzed with the view of finding such a force, assigns to it such a long period that we have no clue as to its origin. *A priori* the most probable disturbing body would seem to be Saturn. It must act in the same sense as Jupiter, although to less extent. The spot maxima or minima should be particularly pronounced when the two planets are in conjunction with the sun—that is, every 20 years. Here again the evidence is negative.

We get an even less favorable answer from the rest of the planets. Either their revolution periods are too short to render an account of an 11-year fluctuation or their distances too great for their action to be sensible compared with that of Jupiter.

THE PLANETS AS A DISTURBING ELEMENT IN THE SOLAR CYCLE.

No planet then, or combination of planets seems to be the principal cause of the solar cycle. We may, however, suppose that this or that planet may for a brief time trouble the cycle by rendering the distribution of spots irregular in longitude.

The sun rotates with reference to the fixed stars once in 25 days. The planets revolve about it in the same direction, but more slowly. Therefore, to an observer on the sun, the successive passages of a planet over his meridian occur in periods somewhat longer than 25 days, tending to approach this (sidereal revolution) as the planet's distance increases. This is called the synodical rotation. That corresponding to the transit of the earth is 27.35 days.

Considering now the extreme mobility of the solar surface, we will see whether each planet does not produce a tidal wave which passes over the sun's surface with the corresponding synodical rotation period and capable of producing visible disturbances.

According to the elementary law of Newton, the relative importance of the tidal waves for the various planets is given by what we may call the deforming factor, the product of the mass by the inverse cube of the distance. If we make the value of this factor unity for the earth, the mean values for the planets are as follows:

Mercury	1.04	Jupiter	2.20
Venus	2.09	Saturn	.106
Earth	1.00	Uranus	.019
Mars	.03	Neptune	.001

We see that the most active cause for a tidal wave lies in Jupiter, followed closely by Venus. Mercury and the earth come next, the remaining planets being much less active.

Although the earth comes only in the fourth rank, we will consider it first because we are better situated for examining its effects. At each instant we can consider the sun as divided into two equal hemispheres, one visible, the other not. The limiting meridians turn uniformly over the surface of the sun in 27.35 days, the synodical period.

Let us first suppose that the earth has no physical influence on the development of the spots. The ratio between the total sun-spot areas in the two hemispheres may happen to have any value whatever; but the mean value taken over a long period of time embracing many synodical rotations, say for a whole solar-spot cycle, should differ very little from unity.

We can not at any given moment count or measure the spots on the invisible hemisphere. But we can count the spots which appear on the eastern border and compare these with those which disappear in the corresponding time limit at the western border. The ratio of the two numbers would have a tendency to surpass unity if it is at a time of decrease in spots and to be less than unity if in the increasing phase. But taken over a whole cycle, the mean value should differ very little from unity.

Now let us suppose that the earth does have a physical influence, for instance, to fix our attention, that the presence of the earth above the horizon of some point on the sun favors the development of a spot at that point. As this development is certainly not instantaneous, any more than is its disappearance, more spots will be born in the visible hemisphere than in the opposite one. Consequently, more spots will disappear over the western border than appear at the eastern. The inverse inequality will be observed, provided we observe over a sufficiently long period, if the presence of the earth causes the disappearance of spots.

Instead of comparing the eastern with the western border we could compare the two halves of the visible disk, the right with the left, and the result would be equally decisive. Practically, if the action of the earth on the solar surface is real, the action will necessarily take a certain time to become manifest. Considerable masses must be moved, masses doubtless subject to interior friction. It is so relative to terrestrial tides which at any point of the earth suffer a variable retardation, but always very marked with reference to the passage of the moon over the meridian. If the earth has no influence, the two halves—the right and left—would, if considered over a sufficient time, show the same number and same area of spots. If the earth has a real influence there will be found a persistent and systematic inequality.

RESEARCHES OF MRS. MAUNDER, 1907.

Mrs. Maunder undertook to answer this question, utilizing the photographs due to a co-operation of English observatories for the interval 1889 to 1901, extending from one spot minimum to the next. At the beginning and the end the sun seemed absolutely free from spots. In every instance the rare survivors which could be found at the beginning and the end of the period upon the visible hemisphere could not vitiate the conclusions derived from all the observations.

The tables obtained at Greenwich comprised—

(1) The positions and areas of the groups for each day.

(2) The history, day by day, of each important group; the areas are expressed in millionths of the visible hemisphere and are corrected for the effect of perspective; the mean duration of a group is about 6 days; 2,870 groups were studied.

Mrs. Maunder divided the visible hemisphere at each instant into 14 vertical zones, each 13.2 degrees wide and numbered in the inverse order of their appearance. For each zone and the entire period the sum representing the area of the spots was made. These results were compared for zones symmetrical to the central meridian. There was thus made manifest a systematic variation from two points of view:

(1) Despite the perspective correction, there was a constant progression on each side in passing from the limb to the central zone, as if the perspective correction had been insufficient.

(2) For each pair of zones there was a constant decrease in passing from the eastern to the corresponding western zone. The same thing was noted when in a similar manner the northern and southern hemispheres were treated separately.

Various reasons make the measures on the extreme zones less trustworthy, but even if we omit them the same conclusions result. If refraction in the solar atmosphere plays a part it would unduly enrich the extreme zones. Accordingly, if a correction is made for it, it but increases the first anomaly. Neither anomaly can be due to errors of observation or reduction.

If we do not like this process of treatment we need not depend upon the areas of the spots, but count simply the number of groups visible in each zone, omitting those of long life which necessarily appear in both halves. Here again, for all pairs of zones, the eastern one shows a greater number than its corresponding western one.

We next ask whether there is, either in the visible or in the invisible half, an habitual and systematic excess in the number of spot births over deaths. *A priori*, it seems as if it must be so for one or the other hemisphere during the phase of increasing spots, but that an equilibrium must be established when a complete cycle is considered.

To throw light on this point Mrs. Maunder associated on each half of the disk the two extreme zones and compared the number of groups of spots which had been seen in each of the two double zones. The predominance was clearly in the eastern pair. There are throughout a cycle more spots seen near the eastern border, and consequently for the whole visible hemisphere and whole cycle there is an excess of disappearances over appearances of spots. The opposite must hold on the invisible hemisphere, since at the beginning and end of a cycle the sun is entirely free from spots.

Neglecting the extreme zones, where the disappearances may be more subject to error, there was obtained for each zone the number of spots which were seen in it for the first time and the number seen in it for the last time. The following result was noted:

As we go from east to west, crossing the visible hemisphere, there is an almost constant diminution in the number of spot appearances over a whole spot cycle and as nearly constant and even greater augmentation in the number of disappearances.

When we compare two symmetrical regions of the disk, the number of births found in one is generally smaller than the number of disappearances in the corresponding region on the other side of the central meridian.

If we were dealing only with numbers, the departures noted might be considered as resulting from a psychological cause. It is probable that there is in an observer a certain, perhaps unconscious, laziness which keeps him from recording new appearances and prolonging old spots unless absolutely necessary. It is always more agreeable to register a disappearance which simplifies work rather than an appearance which augments it.

Thus, when a new small spot appears for the first time, there is a tendency to include it among those already noted rather than to regard it as an advance guard or germ of a new group. If the first impression is wrong, then there results an unjustified diminution of births in the visible hemisphere.

In a similar manner, if a small group approaches a more important group, either by expansion or derivation, there will be a tendency not to consider it separately and to cease counting it as soon as the separation between it and the larger group ceases to be distinct. We are thus led to credit fictitious disappearances to the visible hemisphere.

Both these considerations lead us to record more disappearances than births. But these errors in counting do not explain why the total area of spots is regularly found greater in the eastern half of the visible disk. Considering all of Mrs. Maunder's results we are led to think that the presence of the earth above the horizon of a place on the sun tends to make spots there disappear.

(To be concluded.)

Selenium Cell Making

Within a late period almost all selenium cells are made by using a flat slab of insulating material with a double winding of rather fine platinum wire, upon which the selenium is spread. While many commercial cells use steatite as a base, amateurs will find this material not only hard to obtain, but very difficult to work, owing to the great hardness of steatite. A good substitute is slate, in the ordinary thin slabs, which can be easily sawed in small oblong pieces, and then these are scraped down with a knife so as to give a somewhat elliptical section in order to have the wire lie on well, the edge being rather fine, but not enough so to cause breaking. Great care should be taken to have a clean fresh surface and not to impregnate the very porous slate with impurities by handling with the fingers, which would spoil the insulating properties. One of the main things in a cell is to have the wire mathematically spaced. Grooves are cut along in the edges only (not on the surface), but it is out of the question to make measured marks by the eye, or to cut such grooves other than by machine. Of course a skilled person could easily design a cutter wheel machine for such purpose, but any amateur can make a sufficient cutter by mounting a flat wood block or cell-holder to travel along between two guides (rulers). At one end of the main base is fastened a small block carrying an inserted fixed nut in which moves a piece of threaded rod; on the outer end of the rod is a large wood disk, while the inner end pushes the carriage along upon turning the screw. The cell is clamped on the block carriage. Half a turn of the screw thus drives the carriage along any one millimeter each time. The edge of the cell projects over the carriage. Cutting could be done by a small wheel at one side, but it is sufficient to mount a small fixed block very near the edge of the slate and use it as a guide for a flat saw blade, by which very accurate cutting can be done.

Gyrostatic Action—II*

As Applied to Torpedoes, Submarine Craft and Aeroplanes

By Jas. G. Gray, D.Sc., F.R.S.E.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2045, Page 173, March 13, 1915

ATTENTION is now directed to Fig. 7, which shows a new form of stilt top. A gyrostat is pivoted within a structure terminating in two stiff legs. When the feet of the top are supported on a table, with the plane of the frame vertical, the line of the pivots which carry the gyrostat is sloped to the vertical, and with the direction of slope indicated it will be seen that when the plane of the fly-wheel coincides with that of the frame, the weight W is constrained to move, relatively to f, in a circular path whose highest point coincides with that occupied by W in the figure. Thus in the position

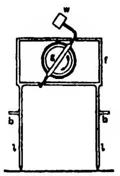


Fig. 7.—Stilt-top.

shown the gyrostat, in consequence of the presence of the weight, is unstably mounted on the frame. Further, the frame is unstable about the line of contact of the feet with the table. Thus the gyrostat possesses two instabilities without rotation of its fly-wheel. If the wheel is rotated rapidly in either direction, and the top placed on a table as described, and left to itself, it will balance on the table. It will be readily seen, however, that the stability is not true stability; the balancing action is accompanied by gyrostatic oscillations of increasing amplitude.

Now let the top be spun in the direction indicated in the diagram, and set up in the fork and pedestal mounting (after the manner of Fig. 2) with the frame and fly-wheel in the same vertical plane. As before, the experimenter operates the fork. With the direction of spin indicated, tilting of the frame to one side of the fork causes the weight W to be carried over to the other side. Now, let a side weight W^1 be attached to the frame f. The gyrostat precesses on the frame bearings, and W is carried over to the side of the frame remote from the attached weight W^1. Let the fork be turned by hand in the direction in which the gyrostat precesses, so that it follows up the latter. Providing that the turning of the fork is so regulated that the frame does not overshoot the gyrostat, the latter will continue to turn on its bearings. It is to be observed that at any instant the acting tilting couple is the difference of the moments about the fork axis of the side weight W^1 and W respectively. The effect of turning the fork is to diminish the moment due to W, and the precessional motion is maintained. This action has

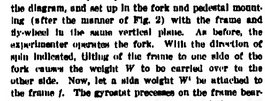


Fig. 8.—Gyrostatic motor-car with electro-magnetic steering device.

been utilized by the author on bicycles and motor cars.

Fig. 8 is a diagrammatic representation of a large gyrostatic motor car constructed on the above principles. The car is entirely stable when moving in the forward direction. It will be seen that the gyrostat stabilizes the car, and at the same time presides at the steering wheel.

The function of the weight W_1 is to apply the necessary tilting couples. W_1 is an arm which is rotated about a vertical axis by means of a small geared electric motor. This motor car is capable of being operated by wireless transmission of electrical action.

It should be noticed in the case of this motor car, as well as the one previously described, that the gyrostat cannot positively lose control. The frame is continually following up the gyrostat, and hence the displacement of the axis of the fly-wheel from the position in which it lies athwart the car never exceeds 30 degrees.

Fig. 9 shows diagrammatically a gyrostatic device adapted for steering a body stable of itself, such as a tricycle, four-wheeled motor car, or torpedo. The gyrostat is mounted on bearings b_1 b_1 carried by a frame f; it is made azimuthally unstable by sloping the line of these bearings to the vertical and attaching a weight W to the frame of the gyrostat. The frame is carried on horizontal bearings b_2 b_2 arranged on pillars p_1 p_1 attached to the moving body. The frame f is rendered laterally unstable on these latter bearings by attaching to it the weights WW as shown. The gyrostat clearly possesses two instabilities without rotation of its fly-wheel. When the gyrostat is suitably connected up to the steering mechanism these two instabilities give rise to complete stability of the gyrostat when the body is in motion. The frame f may conveniently carry apparatus for applying tilting couples to the gyrostat.

In the construction of wheeled vehicles it has been found sufficient to connect up the gyrostat directly to the steering wheel or wheels. In the case where a steering mechanism, such as a rudder or plane, has to be operated forcibly it may be advisable to multiply up the couple transmitted by the gyrostat. A method which has been found highly satisfactory is shown in Fig. 10. One end of a cord is attached to a point on the frame of the gyrostat. The cord is then passed once or more times round a vertical drum or pulley d_1, then round a drum D carried by the rudder post, then round a drum or pulley d_2, and finally fastened to the gyrostat frame as shown. The two pulleys d_1 d_2 which are of equal diameter, are geared up to a small electric motor; they revolve in opposite directions with the same speed. If the gyrostat precesses one of the cords attached to it becomes taut. A small stretching force in the cord on the gyrostat side of d_1 gives rise to a large stretching force in the cord on the drum side of d_1. If the stretching force on the gyrostat side of d_1 is zero, that on the drum side is also zero. It will thus be seen that a small couple applied by the gyrostat results in the application of a very large couple to the drum, and hence to the rudder.

The rudder is shown connected up, so that when the gyrostat precesses the body is steered up parallel to it—that is, so as to maintain the axis of the fly-wheel transverse to the body. A little consideration will show that a ship or torpedo steered by this mechanism will pursue a perfectly straight path.

In the form of torpedo at present in use the gyrostat is freely mounted on gimbal rings. In the absence of a disturbing couple the axis of the gyrostat will retain its direction in space unaltered. Hence when the torpedo deviates in its path a shift occurs between the direction of the axis of the gyrostat and that of the projectile. The apparatus (as used at present) must be made with great precision: notably the center of gravity of the gyrostat must coincide exactly with the point of intersection of the gimbal axes. If this condition is not fulfilled the torpedo travels a curved path.

The existing type gives very good results over short distances; but a gyrostat freely mounted would be useless in a long-distance projectile, even if a motor gyrostat were substituted for the one now employed. This point is not, as a rule, understood. In a dirigible torpedo, properly so called, the gyrostatic mechanism should be such that the gyrostat is endowed with complete stability. This condition fulfilled, the gyrostat can be caused to bring about turning movements of the torpedo by the application to it of tilting couples.

The construction of a very high-speed, long-distance torpedo, to run completely submerged, propelled by power stored within the projectile, is difficult if not impossible at the present time. But a long-distance torpedo, driven by electric power derived from accumulators, and having speed or from 15 to 20 knots, could certainly be evolved. Such a weapon, with a range of action of, say, 100 miles, and possessing the property that it could be set to travel on a prearranged path, would be a valuable addition to British naval appliances. The torpedo, for example, could be arranged to proceed in a straight path from one position A to the neighborhood of a second position B, and left cruising in that neighborhood.

The progress which has been made in the development of the internal-combustion engine renders possible the construction of a torpedo capable of running at high speeds for very lengthened periods without attention or renewal of fuel. Such a torpedo would, however, not be entirely submerged, inasmuch as an air inlet and an outlet for the products of combustion must be provided. To steer such a torpedo from a fixed or moving station, it would be necessary to connect the torpedo to

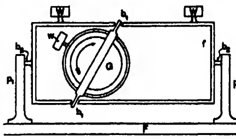


Fig. 9.—Gyrostatic control for torpedo or airship.

the station by means of a pair of fine wires, which could be paid in or out as desired. This torpedo, brought to perfection, would be a formidable weapon with which to fight submarines. The directing of torpedoes by the wireless transmission of electrical action is not practical at the present time. To be effective the sending apparatus at the receiving station would require to be tuned to the receiving apparatus on the torpedo beyond the possibility of interference from without.

The principles which have been explained seem particularly well adapted to give results when applied to problems of aviation. It will be seen that a gyrostat mounted on an aeroplane so as to have two instabilities without rotation of its fly-wheel, and with its axis across the aeroplane, can be endowed with complete stability by causing it to steer the aeroplane. A gyrostat so mounted is available for operating the balancing planes (the planes which control lateral stability) of the aeroplane. Again, the axis of the gyrostat can be placed fore and aft, and the gyrostat is then available to operate the tilting planes (the planes which control longitudinal stability) of the aeroplanes. In order that a gyrostat may be used to operate both the tilting and balancing planes of an aeroplane, it must be mounted on the aeroplane with its axis vertical. To obtain stability of the gyrostat it should be provided with two stabilities with rotation of its fly-wheel, and caused to operate the tilting plane of the aeroplane. It could thus to completely stabilised, and would then be available for operating both sets of planes.

Objections have been taken to the use of gyrostats on aeroplanes, and it is certainly true that there is no point in utilising gyrostatic action in cases where the desired results can be obtained equally well without the application of such action. But the author is convinced that it is possible to contrive gyrostatic controls for aeroplanes which would be perfect in action, and the utility of such aeroplanes is readily seen at the present time. Aeroplanes and airships, capable of being steered

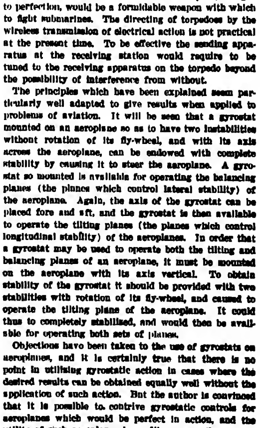


Fig. 10.—Control for ship or torpedo, with stabilized gyrostatic system.

* *Transactions* of the Institute of Engineers and Shipbuilders of Scotland.

in a horizontal plane, lofted or depressed, by means of electrical action transmitted from a fixed or moving station would certainly be of value to this country at the present time. Such contrivances provide a method of fighting Zeppelins and of bombarding an enemy's lines and fortifications.

In conclusion, it might be pointed out that the ship, torpedo, aeroplane, and airship controls which have been described could only be brought to perfection on a large scale as a result of experiment and trial. Such experiments are not possible to a private individual. The principles to be employed have been evolved as the result of much research work. It has been said that the motor-gyrostats required would be difficult to produce. This is not the case. Careful calculations have been made relating to the size and power of the motors, and these would certainly be forthcoming.

There can be no doubt that the present-day applications of gyrostatics to warfare are mere shadows of what is to come in the near future, and this being the case, it is a matter of supreme importance that Great Britain should lead the way in the scientific advancement of the subject. A distinguished gyrostatic inventor from abroad recently informed the author that he regarded Glasgow University as the home of the gyrostat. It is to be hoped that Glasgow University may be allowed to take part in future developments.

Discussing this paper, Prof. Andrew Gray, LL.D., F.R.S., said he supposed he was to some extent responsible for the apparatus and experiments which had been shown. Each of the items which they had seen might form the subject of a separate lecture. It was very difficult to give a full account of so many things. There were a few points about which he might perhaps say a word or two. One was the steering of airships, aeroplanes, and so on. He was not sure that it was made perfectly clear that these could be steered without an aviator or steersman on the machine. They could be steered from any place of observation, and without any trailing wires at all, so that it was possible to send a torpedo to its destination by any desired path, however circuitous, without any risk of loss of life to the attacking party. Also, the range of torpedoes could be immensely increased. At present, if a ship has to discharge a torpedo it has to get fairly close, and in doing so it might be disabled by gun fire: but if the range of the torpedo could be greatly increased the attacking party would be at a great advantage. It was difficult to interest official people in new inventions, and perhaps considering the enormous number of fantastic ideas published, and even patented, that is not to be wondered at. An official was continually guarding his chief from the attacks of people outside—acting, in fact, as a kind of torpedo net for him. In the course of the lecture they had been told more than once that these gyroscopes had two instabilities without rotation. These two instabilities were converted into two stabilities by rotation. But it was not possible to stabilise an odd number of instabilities. For instance, if there were three freedoms they could not stabilise all three; they might stabilise two of them. This was a rather important mathematical theorem. There was still a great deal to be done from the theoretical point of view; but by Dr. Gray's apparatus one did obtain some verification by experiment of the truths of the dynamical results which had been worked out.

Gasoline from "Synthetic" Crude Oil*

Some Remarkable Experiments With Oils and Method of Obtaining an Additional Yield of Gasoline

By Walter O. Snelling

In the course of some experiments more than five years ago, made for a totally different purpose than the investigation of the oil used, I placed a small quantity of a transparent yellow lubricating oil in a bomb-like vessel and heated it to a relatively high temperature. At the end of the experiment I removed the oil from the vessel and was amazed to find that instead of bearing any resemblance to the oil which I put in, it now had the appearance of ordinary crude oil. The green color by reflected light and the rich red-brown by transmitted light were so unmistakable as to at once lead to further investigation. I subjected the material to fractional distillation, and the surprise which I experienced at the *appearance* of the oil, changed to amazement when I found that it yielded, on distillation, 15 per cent of gasoline and 30 per cent of burning oil, and that its constitution resembled crude oil quite as much as did its appearance. Furthermore, the gasoline and kerosene distillates which it yielded were of a clear water-white color, entirely without treatment with acid or alkali, and were entirely free from the odor familiar in "cracked" petroleum distillates.

The result of this experiment was quite too remarkable to be credited without further confirmation, and I at once filled the vessel with some of the same oil that I had used before, and again heated to about the same temperature that I had previously used, and for the same period of time. Upon opening the vessel and removing the contents I found, not the material resembling crude oil that I had obtained before, but apparently only the same oil that I had put in, somewhat darkened in color, but nevertheless far different in appearance from the material obtained in the previous experiment.

Evidently some condition existed in the first experiment that had not existed in the second test, and here began a series of tests in which I sought by the change of one variable after another to arrive at the identical conditions which must have existed in the first experiment. Only the fact that the bottle of heavy oil used in the first test was still in its place, and the further fact that I had no crude oil among the materials at hand when I began the experiment—only these facts kept me from believing that I had indeed made some mistake, and that crude oil had in some manner found access to my apparatus.

After many fruitless experiments I learned a fact which should have been obvious to me from the first, but which in the surprise due to the unlooked-for result obtained, had quite passed out of my mind. In my first test, the vessel which I used had contained but a little oil (about one fourth of the volume of the vessel only), and in all of the other experiments I had filled the vessel three fourths full or more in the effort to obtain as much of a yield as possible.

I repeated the first experiment, using the vessel but one fourth full, and heating to about the same temperature, and for the same time as I had done in the other experiments. The result was once more the greenish liquid so familiar to anyone who has lived in the oil fields, and its fractionation again gave 15 per cent of gasoline, 30 per cent of the burning oil, etc.

Apparently some remarkable change must come about in the hydrocarbon molecules, when a hydrocarbon body is heated in a still only approximately one fourth full of oil, that does not occur when the same hydrocarbon is heated under similar conditions, except that a greater proportion of the volume of the still or retort is filled with oil. With grave doubts and fears, I placed in my retort some kerosene. If this water-white material, after treatment, should come out green in color by reflected light, and red by transmitted light, then indeed I would be convinced that I was dealing with a true transformation into crude oil. The experiment ended, I poured out from the vessel a liquid which resembled Pennsylvania crude oil so perfectly that when I placed a bottle of the new product by the side of a bottle of the real crude, it was hardly possible to say which was which, by appearance alone. I next melted some paraffin and placed it in the vessel, and after heating under the prescribed conditions, I poured out a thin fluid, suggesting crude oil in every way, and which on distillation gave somewhat over 15 per cent of a water-white gasoline, free from "cracked" odor, and other distillates in about the same relationship as in ordinary crude oil.

One after another I tried putting all natural hydrocarbons available to me through this process. Vaseline, rod wax, gas oil, fuel oil, and B. S., all these went into my treating vessel, one after the other. They all yielded materials similar in appearance, odor, and composition. From any of these materials I obtained a synthetic crude oil containing around 15 per cent of gasoline, and other distillates in about the same order as are found in typical crude oils.

After many experiments had shown me the exact conditions of temperature, pressure and filling volume of my treating vessel which were necessary to success, I fondly imagined that my troubles were over. I did not for a moment think that human nature would involve greater difficulties than had even the control of natural conditions. Full of enthusiasm, I described the results of my experiments to an oil man, without of course describing the exact process on which I had not yet applied for patent. He listened to me carefully and kindly, but his look of utter unbelief and incredulity was a trifle galling, to one whose life work had been devoted to scientific investigations. Had I been a promoter, selling stock in a gold mine located at Hackensack, or in a diamond mine on the outskirts of Brooklyn, I could hardly have met with less encouragement, or more entire disbelief.

To-day, when processes for increasing the yield of gasoline are being worked on by many investigators and when such lines of work are being encouraged and lavishly supported by a number of oil companies, and are being paid for in many cases with sums far greater than any probable returns, it may be hard for you to realize that only five years ago the shortest cut to suspicion and doubt, from your friends in the oil business, was even to suggest gently in ordinary conversation that perhaps by some method it might be possible to materially increase the ordinary yield of high grade gasoline from crude oil. I tried it a few times, picking out the most kindly and genial of my friends in the oil refining line. They would look, first pityingly, and then suspiciously, and would say "but after you have gotten out the gasoline that is present in crude oil, how do you think that you are going to get any more? Don't you understand that when you have gotten it *all* out why you have gotten it all? What is left then is kerosene, gas oil, or what not. But it is not gasoline."

Only once did I venture mildly to protest. I suggested that possibly, since hydrocarbons were all compounds of hydrogen and carbon, it might be possible to rearrange the atoms in the molecule so as to obtain more gasoline. This view met with some recognition, and I was told that what I was talking about was called "cracking," and that it was thoroughly understood by oil men, and that furthermore, "there was nothing in it" as far as making anything salable as gasoline, as the product would invariably be of bad color, and of an extremely offensive odor.

Slowly I came to realize that the oil industry was not yet ready for any new views as wholly different from their preconceived ideas as these experiments made necessary. So I would go back, for comfort, to the water-white gasoline of 70 deg. B., which I had made from paraffin and from kerosene, from gas oil and from B. S., from fuel oil and from rod wax, and patiently wait for the day when my friends in the oil business would realize that there were a few insignificant things about oil which they did not yet know. For their attitude I could hardly blame them, after all, when I remembered my own doubt when I had seen the results of my first experiments. They had not seen them, and therefore if they doubted, I could at least understand their position, and I am hardly prepared to say that I should have been less doubting than they were, had the position been reversed.

This paper makes public for the first time the results of my experiments, and in presenting it I wish to express my indebtedness to Mr. John T. Milliken of St. Louis, Mo., president of the Milliken Refining Company. He was the first oil man whom I met, who was willing to believe that research could really add materially to the oil man's knowledge. He has generously supported the experiments which I am now reporting, and has supplied the financial help which alone has made this paper possible to-day.

It has long been known that under the influence of high temperature hydrocarbon bodies could be thermolized or "cracked," and that by this method low boiling bodies could be produced from hydrocarbons of higher gravity. Indeed, the commercial use of cracking distillation in petroleum refining goes back from more than half a century, the first observation of such cracking distillation being said to have been made accidentally, in a refinery at Newark, N. J., during the winter of 1861-2.

For thirty years after the discovery of methods suitable to cracking distillation, this method was in common use in many of the principal oil refineries of the world. It was found that by running the stills at a high temperature very considerably increased yields of kerosene could be obtained, and the method was found to be a profitable one from the start, particularly since in the early days of the oil refining industry, burning oil or kerosene was the principal product sought for. The process was also investigated by many able men, and the condition under which long paraffin chains became broken into two or more shorter chains, under the influence of high temperatures were very carefully

* Paper read at the February meeting of the American Institute of Mining Engineers.

worked out, particularly as concerns commercial refining operations.

Accordingly it was only natural that, with the enormous increase in demand for gasoline during the past ten or fifteen years, many investigators should attempt by similar cracking methods to obtain increased yields of low boiling products. When the vapor of kerosene or any heavier oil is passed through a red-hot tube, for example, thermolisation takes place with the production of considerable amounts of low-boiling products vaporizing within the ordinary boiling points range of common gasoline. In this, and in many other similar ways attempts have been made both on a laboratory scale, and in large-size commercial installations, to prepare products capable of replacing gasoline. Of the dozens, or even hundreds, of such efforts, few have had even the slightest promise of success, due to the fact that the low-boiling hydrocarbons produced in the manner described are off-color, and possess an odor so pronounced and disagreeable as to greatly limit, if not wholly prevent, their sale. So acute has been the demand for gasoline at times in the past ten years, that it is not impossible that even the color and odor might have been overlooked if the process had given the large yields that were originally hoped for, but in this respect also the ordinary cracking methods have met with difficulties, and in general all these processes produce considerable amounts of tar and coke, that materially cut down their efficiency.

When the limitations of simple cracking of hydrocarbon oils at ordinary pressures were first understood, efforts were made to bring about destructive distillation under increased pressure. Results showing great improvement over those obtained by the simple cracking methods were given by these processes, which seem to have been first made use of by J. Young, and later developed by Dewar and Redwood, and others. Quite recently improved processes of cracking distillation under increased pressures have been used commercially by Burton, and are said to have been so developed as to yield products readily salable as substitutes for gasoline.

Efforts have not been wanting to improve the color of and odor of the light cracked distillates produced by ordinary cracking distillation. Treatment with sulphuric acid and alkali, in the manner commonly used in the refining of kerosene, have the effect of improving both color and odor to a remarkable extent, and by the use of sufficient acid colorless products without bad odor can be obtained, but only by the use of such large amounts of acid as to make the process commercially prohibitive, unless gasoline is selling at quite a high figure. By cracking under increased pressure the amount of acid required for this purification is very greatly reduced, and it is probably due to this fact that the motor gasoline now being so extensively developed by Burton owes its greatest commercial possibilities.

It will thus be seen that I cannot claim to be in any way a pioneer in the production of lighter hydrocarbons from materials of heavier gravity. Hydrocarbons have been cracked and broken up into lighter hydrocarbons of lower boiling point, both experimentally and commercially for a period of over fifty years, and such cracking experiments have been conducted both at normal pressures, and under increased pressures.

Other investigators have also placed hydrocarbon oils within closed vessels and have heated these oils under such conditions to elevated temperatures. In such work Engler, in particular, has made notable contributions to our knowledge of the behavior of hydrocarbons under high temperature and pressure. In these experiments it has been noted that the hydrocarbons have been broken down to lighter hydrocarbons, and that in this way low-boiling oils could be made from hydrocarbons of high boiling point. Apparently, however, the remarkable influence which is played by the ratio of the liquid contents of the vessel to the total volume of the vessel, has been either wholly overlooked, or at least not properly appreciated. It has been wholly through the investigation of the effects of the ratio of the volume of oil, to the total volume of the vessel, that I have developed the process which I am here describing, and which has given the remarkable and unexpected results already mentioned. I believe it is only when these suitable volume relationships are observed, that we can get these results within a range of temperature and pressure adapted to commercial development.

Very careful studies made in my laboratory have now proven that, when a hydrocarbon body, such as gas oil for example, is heated in a vessel which is filled to more than one tenth of its volume with such oil, but such filling is less than one half of the total volume of such vessel, and if then the vessel is so heated that a pressure of say 800 pounds per square inch exists within the vessel, a very remarkable and fundamental change occurs in the hydrocarbon filling such vessel. It is as though the carbon and hydrogen atoms were free to rearrange themselves, and that such rearrangement goes on until a more or less definite mixture of hydrocarbons remains in the vessel. Where the vessel is less than one tenth filled with oil, considerable "cracking" seems to take place and the product is quite inferior. Where the vessel is much more than one half filled with oil, the reaction seems to fail almost wholly, the amount of light products produced being very small. But when the conditions within the vessel, as to amount of filling, and temperature applied, are as indicated above, the carbon and hydrogen atoms of the hydrocarbon seem to rearrange themselves to form crude oil and natural gas.

In this rearrangement, not only are low boiling compounds produced from those of higher boiling point, but even the reverse action takes place. In several tests I have obtained from petroleum products of medium boiling point synthetic crude oils which contained high-boiling ends, whose boiling point was considerably higher than any of the constituents present in the original oil used. Apparently the entire process depends upon certain equilibrium reactions, in which constituents of different boiling point tend to be present in a certain very definite ratio, provided the space relationship within the treating vessel is of the proper order. Solid paraffin of course contains no constituents that are liquid or gaseous at ordinary temperatures, but upon treatment by this process even this solid paraffin is resolved into synthetic crude oil and natural gas, and the percentage of products of each definite boiling point appears to be in a definite condition of equilibrium. If instead of starting with paraffin, we go to the other extreme, and start with kerosene, which is entirely free from heavy ends, we will obtain a synthetic crude oil which is much lighter in gravity than that produced from paraffin, but which nevertheless contains high boiling constituents whose boiling point exceeds by many degrees the boiling point of the heaviest product present in the untreated kerosene. Thus, it will be seen that while this process is primarily one in which heavy hydrocarbons give crude oils containing light distillates (this being the main trend of the reaction), yet the process is so essentially one dependent upon equilibrium, that if high boiling constituents are absent, or present in very small amount, the equilibrium will not be satisfied until additional amounts of these high boiling constituents have been produced as the result of the reaction which is going on.

A residual pressure, after cooling, always exists due to the natural gas formed in the process, and the amount of gasoline in the synthetic crude oil, seems to be very constant no matter what hydrocarbon is taken. It is of course evident to the chemist that natural gas and gasoline contain a greater percentage of hydrogen than do heavier oils, and it is very interesting to note that when the charge which is placed within my treating vessel contains a hydrocarbon deficient in hydrogen, the formation of saturated gasoline goes on just the same, and the synthetic crude oil produced carries a "mud" consisting of the carbon which in the rearrangement has failed to find hydrogen. The gasoline produced from materials even highly deficient in hydrogen is quite normal in color, and does not appear to be in any way like the "cracked" products which are produced by the thermolysis of oil vapors, etc.

The following results of runs made by this process, in one case starting with solid paraffin wax, and in the other case with Oklahoma gas oil, will clearly illustrate all the technical features of the method.

TEST 1.

Material used, solid white paraffin. Melting point, approximately 120 deg. Fahr. (50 deg. Cent.). Specific gravity 0.925 (21.5 Be.). 300 cubic centimeters taken. Capacity of treating vessel used, 1,100 cubic centimeters. Heated until pressure of 800 pounds was indicated, then cooled. Pressure of residual natural gas, 130 pounds. Product after treatment, a heavy liquid, resembling "Franklin heavy" Pennsylvania crude oil. Color, dark green by reflected light, deep red-brown by transmitted light. Volume of synthetic crude oil obtained as result of run, 305 cubic centimeters (5 cubic centimeters increase in volume, over the amount of liquid paraffin started with). Specific gravity of this synthetic crude oil, 0.770 (0.51.9 Be.). Gasoline yield, on distilling this synthetic crude oil to 150 deg. Cent., 48 cubic centimeters. Gasoline in synthetic crude oil, 16 per cent. Specific gravity of this gasoline, 0.70 (70 Be.). Color, water-white.

TEST 2.

Material used, Oklahoma gas oil. Specific gravity, 0.850 (34.5 Be.). 300 cubic centimeters taken. Capacity of treating vessel used, 1,100 cubic centimeters. Heated until pressure of 800 pounds was indicated, then cooled. Pressure of residual natural gas, 120 pounds. Product after treatment, a liquid resembling Pennsylvania mixed pipe-line crude. Color, dark green by reflected light, deep red-brown by transmitted light. Volume of synthetic crude oil obtained as result of run, 288 cubic centimeters. Specific gravity of this synthetic crude oil, 0.861 (88.5 Be.). Gasoline yield on distilling this synthetic crude oil to 150 deg. Cent., 40.9 cubic centimeters. Specific gravity of this gasoline, 0.705 (68.5 Be.). Gasoline in the synthetic crude oil, 13.6 per cent. Color, water-white.

It is of course evident that if putting any hydrocarbon through the process described makes it into a crude oil, it ought to be possible to take any hydrocarbon, and first convert it into crude oil by the process described, then remove the gasoline, for example, or any other constituent, from this crude oil by distillation, and then to subject the residue to a repetition of the process. I have done this many times, and have converted paraffin and other petroleum products almost wholly into gasoline and natural gas. I have obtained from paraffin about 70 per cent of water-white gasoline, the remaining 30 per cent representing the natural gas formed by the repeated action of the process, and some free carbon. From fuel oil, gas oil, vaseline, and similar materials, I have obtained from 50 per cent to 70 per cent of water-white gasoline, and samples of this gasoline, even after standing for a year or two, do not discolor, nor acquire an offensive or "cracked" odor. I wish to particularly note that this gasoline, even when produced, was not treated in any way, and has never come in contact with either acid, alkali, Fuller's earth, bone black, or other related materials. In brief, the process which I have described produced from practically any hydrocarbon, a material which resembles natural crude oil, and which gives a gasoline which appears equal in quality and appearance to gasoline from natural crude. Both the crude oil produced by my process, and the gasoline produced from its distillation, possess an odor which is somewhat different from the odor of natural crude oil and ordinary gasoline. This odor, while peculiar and distinctive, is not in the slightest like the odor of "cracked" products, and it is in fact a slightly milder and sweeter odor than that of ordinary oil products. Upon mixing my synthetic crude oil, or the gasoline produced from it, with certain muds and clays, it seems to be altered, and the odor changes and becomes much more like that due to ordinary crude oil. Personally I am of the belief that crude oil in nature has in some cases been produced by some process related to that which I have here described, the effect of the high temperature which I use for a short time having in earth history been produced by very much lower temperatures acting through geological ages. I believe the condition which in my report is represented by about three fourths open space, in nature has had its equivalent in the open space in the sand or other porous rock which has been the repository of the oil, and I believe that natural gas which is so commonly associated with petroleum deposits has had a related origin in nature to that which it has in the process worked out in my laboratory experiments.

The study of the genesis of petroleum is so involved that I do not wish these suggestions to be taken in any way as other than ideas which have forced themselves on my mind after noting the very considerable similarity in appearance and constituents which exists in most of the petroleums of the world (except when a porous cover, or other well recognized conditions have allowed the more volatile materials to vaporize, or other well-known oxidation or other phenomenon to take place), and its seems more than likely to me that any process which in the laboratory will produce materials of such similar appearance and composition from raw products of the most diverse nature, must surely have some connection with the conditions which in geological time have similarly produced from starting out products of many different kinds, a material possessing such well-marked and easily recognized characteristics as petroleum.

One very interesting development in connection with this work has been the effect of small amounts of certain catalytic materials, in facilitating the transformation into synthetic crude oil. The addition, to the oil to be treated, of even a very minute amount of colloidal graphite reduces materially the temperature and pressure at which the process is operative. In one set of experiments, in which a given treating vessel gave synthetic crude oil at an average treating pressure of 850 pounds, it was found that the addition of a small amount of finely divided graphite would lower the necessary treating pressure to 750 pounds, or even to 700 pounds, on somewhat longer treatment. This seems to offer confirmation of the theory which I have advanced, that the entire process is dependent on certain reversible reactions which under the described conditions reach an equilibrium when sufficient time is given. The action of finely divided catalytic materials in increasing the speed of reactions is well-known, and in these experiments their function seems largely to be the increasing of the rapidity of the equilibrium reactions, so that the reaction goes on more easily by

completion in the very brief time of the test. In my experiments our general procedure has been to heat the treating vessel until the desired pressure is indicated, when the heating is at once stopped, and the treating vessel cooled and emptied. We have found that when, instead of raising the pressure to the desired treating maximum, and instantly cooling the vessel, we raise to a somewhat lower temperature, and maintain this temperature for five or ten minutes, we get practically an equivalent result. Where a catalyst is used, as described, it is possible to use a much longer pressure, and still obtain a normal synthetic crude oil.

These experiments which I have described have been wholly of a laboratory nature, and much work remains to be done in the application of the principles which have been discovered, to commercial work on a large scale. While it may seem to many that the pressures and temperatures employed are so high as to preclude the possibilities of commercial work, yet I do not think this is the case. Processes have been developed abroad, during the past few years, in which ammonia is made synthetically by reactions requiring both higher pressures and higher temperatures than those which are made use of in my present work. As these ammonia researches have gone on, from their laboratory inception to their commercial development upon a very extensive and successful scale, I believe the present process will find similar development comparatively easy. The conditions necessary for successful commercial work are already well known, and involve no engineering features which American ingenuity cannot easily provide, and it is my hope that this process will be soon developed to the point where it will fulfill commercially the remarkable promise that it now seems to offer.

Hydrogen and the Rare Gases*

THE series of Friday evening discourses at the Royal Institution was once more opened this year, on January 22nd, by Sir James Dewar, F.R.S., by a lecture on "Problems of Hydrogen and the Rare Gases." Last year Prof. Dewar, discoursing on "The Coming of Age of the Vacuum Flask," and on researches which the use of his vacuum vessels, of charcoal, and other modern expedients had rendered possible, had dwelt on the difficulties of separating and eliminating the rare gases and upon the apparent ubiquity of the lightest of all gases—hydrogen. In the lecture of January 22nd he gave a brief, essentially experimental, *résumé* of further researches, by himself and others, in this field. At 20 deg. Cent. absolute, he pointed out, nitrogen and oxygen were frozen hard, and their vapor tension was so low that they disappeared from the air, leaving only the uncondensable gases, representing about 1/50,000th of the volume of the air, corresponding to a barometric pressure of ½ millimeter. When air was deprived of its oxygen by chemical means, and the remaining gases were condensed at 20 deg. Cent. absolute, there should be 29.7 parts per million of uncondensable rare gases left. But much larger amounts were often found; it depended upon the chemical used for absorbing the oxygen. Of these reagents sodium hyposulphate answered best, as it gave 29.7 parts of residual gas. Copper also answered well, yellow and red phosphorous less well; in the latter case the gas, after the removal of the hydrogen in it, amounted to 26.7 parts. Chromous chloride was one of the most striking cases; from 68 to 20,300 parts of gas were found in different experiments, and after removal of the hydrogen, 31 parts remained. The excess of gas was, as already indicated, hydrogen, which found its way into the apparatus with the reagents or by other means.

In order to investigate these problems it was no good to start with large volumes of gases. Sir James exemplified this by showing a skeleton cubic meter with a cubic centimeter inside. Special means had to be devised to experiment with small quantities at the time, to accumulate the effects. The gas absorption by cooled charcoal was very serviceable. Sir James showed, with the help of two barometric tubes, how much more quickly the absorption proceeded when liquid hydrogen was used than when liquid air was used. Studying the air respired by eight different persons in this way, and working again at 20 deg. Cent. absolute, he found from 22 to 52 parts per million of uncondensable gas in the respired air, of which sometimes only two parts, sometimes more than 20 and 30 parts, were hydrogen; the amounts varied with the time of the day and other conditions. Animals also produced hydrogen in similar quantities, and ordinary air contained about 0.8 part of hydrogen per million. The identification of the gases was effected by passing the electric discharge through them and studying the spectra. In a pretty, novel experiment Sir James passed the discharge through a tube containing a mixture of gases, first at too high a pressure to show a good glow; he then touched one portion of the tube with a sponge dipped in liquid hydrogen. So much gas was condensed inside at that spot that the discharge striæ of the gases at once began to appear in the other parts of the tube.

Unfortunately, Prof. Dewar proceeded, charcoal absorbed even the rare gases to some degree, and it had its peculiarities. Two tubes were provided with charcoal bulbs, and charged with air; the air in the one tube only had been dried by being passed through liquid air. When the bulbs were afterwards heated (by being dipped into warm water instead of liquid hydrogen), the liberated gas in the one case was essentially oxygen, and in the other essentially nitrogen, the gas extinguishing a burning taper in the latter case. Passing to the occurrence of the rare gases in air, water, thermal springs, sea-water, etc., Sir James pointed to the researches of Moureu and Lepape, according to whom the ratios of krypton to argon, and of xenon to argon, were the same both in air and in the French thermal springs, some of which are very rich in rare gases, while the ratio of helium to argon varied enormously; that might be connected with a radioactive source of helium. As regards the proportions of these gases, city air contained 22.5 parts per million of helium and neon and 2.6 of hydrogen, country air similarly 22.8 and 0.5 parts respectively; the air liberated from charcoal at 85 deg. Cent. absolute contained 1.64 and 0.1 parts, and air from a steel bottle (likewise liberated from charcoal at 85 deg. Cent. absolute), 1.53 and 0.8 parts. Gautier had only found a trace of helium in sea-air.

The question arose in such determinations whether the frozen oxygen and nitrogen did not occlude any other gases. Under ordinary conditions, Sir James stated, they did not, apparently; but when certain mixtures of gases were tested, an occlusion seemed to occur. Thus, all the nitrogen condensed at 20 deg. Cent. absolute under high exhaust could be regained at + 15 deg. Cent.; so could carbon dioxide; but in mixtures of nitrogen, or of carbon dioxide with much hydrogen (20:80), there was some occlusion, though almost all the occluded gas was liberated again at + 15 deg. Cent. Hydrogen and carbon dioxide, therefore, became together volatile when they had formed a solid solution which was more volatile than carbon dioxide, but less volatile than hydrogen. The minimum gas pressure of chemical nitrogen seemed to be $0.33 . 10^{-4}$ millimeter (the usual unit of pressure in Sir James's experiments); but with the aid of the molecular air-pump [of] Gaedel the pressure could be reduced to $0.07 . 10^{-4}$ millimeter.

The next series of experiments of Prof. Dewar concerned the permeability of metals (hot or cold), like platinum, palladium iron, and also quartz, to gases. This permeability was a source of trouble. The experiments were so conducted that a tube of platinum, e. g., closed at one end, was evacuated and joined to a discharge tube, which would not allow the discharge to pass as long as the gas pressure was too low. An all-pressure gage was joined to the apparatus and the time was measured, so that the rate of the rise of pressure could be watched. When the platinum was heated in a gas-burner, the discharge began to pass, because the hot platinum was permeable to the hydrogen in the gas-flame, so that hydrogen entered the platinum tube. When a quartz tube was pushed over the hot platinum tube, so as to form a jacket round it, the manometer went back, because the quartz was not permeable to hydrogen. This was still more striking when the quartz tube was drawn out so as to allow the introduction of different gases into the annular space. The experiments proved that platinum, heated by a Meker burner, was most permeable to some gas (chiefly hydrogen) when placed in the lower part of the flame, where hydrogen predominates; the curves obtained when the tube was in the middle or in the top portion of the flame indicated a smaller rise of pressure, and a less abrupt fall of pressure again when the flame was removed. An iron tube proved permeable to hydrogen, like platinum; in a palladium tube the rise of pressure was, under the same conditions, much more rapid. When carbon monoxide (supplied strongly compressed) was burned in a Bunsen burner with a pale blue flame, no gas (neither the CO, nor the CO_2 produced by the burning of the CO) penetrated through the hot palladium. Experiments were then made with helium; it was demonstrated that helium easily passed through hot quartz, while hydrogen would not diffuse through hot quartz, though it would readily pass through hot platinum.

The permeability of skins or films of rubber 0.01 millimeter in thickness, stretched over a metallic frame, was also demonstrated, and some surprising results were shown. Oxygen passed more readily through a rubber skin than hydrogen and argon more readily than nitrogen, so that rubber would appear to be more permeable to gases of high atomic weight than to gases of low atomic weight. The wet film was much less permeable; and dry air (dried by being bubbled through liquid air) passed more quickly through the dry film than humid air (from the lecture-room). Dipping the film itself into liquid air would make it impermeable; the same impermeability resulted when the rubber was dipped into gylcerin, which could only be done properly with a dry film. Water vapor found its way also through hot palladium and platinum. These various features, the occlusion of gases, the ubiquity of hydrogen, the permeability of metals and rubber, etc., render the investigation of the rare gases still more difficult than it is otherwise. In his researches on respired air Sir James makes his apparatus entirely of glass and metal; rubber connections and greased stop-cocks, which might give off gas, have to be avoided.

* [illegible] *Engineering.*

Electrical Conductivity Imparted to Liquid Air by Alpha Rays

IN a paper read before the Royal Society of Canada an interesting series of experiments conducted by Prof. J. C. McLellan and Mr. David A. Keys is described. A brief summary of the results is given herewith.

In the published account of their experiments on the measurement of the dielectric constants of different liquefied gases, a number of investigators, including Linde,[1] Dewar and Fleming,[2] and Hasenöhrl,[3] have drawn attention to the high insulating qualities possessed by such liquids. In particular Fleming and Dewar have shown that a small condenser when immersed in liquid air and charged with a Wimshurst electrical machine held its charge perfectly for a period of some minutes. Quite recently, too, Zeeman[4] in studying the Kerr phenomenon in liquid air found when the latter was freed from small ice and carbonic dioxide crystals by filtration, and when precautions were taken to prevent the generation of gas bubbles between the electrodes, electric fields as high as 100,000 volts per centimeter, and even higher ones could be maintained quite readily in the liquid.

Fleming and Dewar in the course of their experiments made a determination of the dielectric constant of liquefied air and also of that of liquid oxygen. The latter they found to be 1.195. If we assume the density of gaseous oxygen at 15 deg. Cent. and 760 millimeters pressure to be 0.00134 (and its density at —182 deg. Cent., consequently to be 0.00424) and its dielectric constant at 0 deg. Cent. and 760 millimeters pressure to be 1.00050, it follows by applying the Clausius Mosotti relation—that K 1 is proportional to the density of the gas—that the dielectric constant of gaseous oxygen at —182 deg. Cent. and 760 millimeters pressure should be approximately 1.0018.

Moreover, as the density of liquid oxygen is about 1.1375, it follows, if we assume the Clausius Mosotti's law to hold continuously in passing from the gaseous to the liquid phase, that the dielectric constant of liquid oxygen should be approximately 1.4821. This, it will be seen, is very close to the value found by Dewar and Fleming in their experiments.

In view of this continuity in the dielectric property of oxygen in passing through the stage of liquefaction, it was thought to be of interest by the writers to see if any indication of a similar continuity could be obtained in the ionization of air by alpha rays when passing from the gaseous to the liquid state.

The results so far reached may be summed up as follows:

(1) In a number of experiments it has been shown in agreement with a number of other experimenters that liquid air when freshly filtered is an extremely good insulator, and that its conductivity in the absence of any ionizing radiation other than that from the earth is much the same as that of ordinary clean air at atmospheric pressure.

(2) The dielectric constant of liquid air was found to be 1.43.

(3) The saturation current obtained in air at ordinary pressure by the complete absorption of the alpha radiation emitted by a plate coated with polonium was found to be about 10 times the maximum current obtained with the highest fields used when the radiation was absorbed in air at 101 atmospheres and about 576 times the maximum current obtained in liquid air when the ionization was produced by the same radiation.

(4) The mobility of the positive ion produced in air at 110 atmospheres by alpha rays was found to be 0.0005204 centimeter second per volt per centimeter, and that the negative 0.000217 centimeter second per volt per centimeter, the latter being about 1.18 times the former.

(5) Evidence has been found in the course of the investigation of the existence of a penetrating radiation emitted by the layer of polonium which furnished the alpha rays.

[1] Linde, *Wied. Ann.* 56, p. 546, 1895.

[2] Dewar and Fleming, *Proc. Roy. Soc.*, London p. 358, vol. 60, 1896.

[3] Hasenöhrl, Leiden. Comm. No. 52. *Proc. Ams. Akad.*, 11, p. 211.

[4] Zeeman, *Proc. Amst. Akad. of Sc.*, January 24th, 1912, p. 650.

NEW BOOKS, ETC.

DIE MATERIE. Von The. Svedberg. Professor an der Universitaet Upsala. Deutsche Ubersetzung von Dr. H. Finkelstein. Leipzig: Akademische Verlagsgesellschaft. m b. H., 1914.

As one reads this extremely interesting and instructive history of the theories of matter, one cannot but be struck by the fact that the conceptions of our latest science are by no means discordant with those that flourished in the days of the ancients. After a certain point is reached in the development of the electronic theory, one necessarily steps across the threshold of science into the realm of metaphysics. When that passage is made, one is startled to find that one is in the company of the Greeks. Books such as that of Prof. Svedberg are always valuable, because they unroll as it were the parchment of the ages, and show how, after all, the most startling and revolutionary and scientific discoveries are but short steps in advance.

IRON NAVY. By Archibald Hurd. With a Preface by the Earl of Selborne, K.G. London and New York: Frederick Ward & Co. 1914. 270 pp. Price, 50 cents net.

It has been the endeavor of the author in this volume to sketch briefly the gradual evolution of British sea power, and to trace the course of that recent rivalry in naval armament which has brought the British Empire face to face with a situation of great gravity. The work opens with a chapter on the creation of the navy, and deals with the period from King Alfred, A. D. 872, to Richard III., A. D. 1475. This is followed by chapters on sea power under the Tudors, including the defeat of the Armada; the seventeenth century navy, marking the triumph over the Dutch; Nelson's early victories, Trafalgar, the Victorian Renaissance; the German Navy Act; the Reform Movement of 1904–1912 The final chapters deal with the composition and distribution of the British fleet, manning, the administration of the navy, and the imperial policy.

ROBERT FULTON, ENGINEER AND ARTIST. His Life and Work. By H. W. Dickinson, A.M.I.M.E., Assistant Keeper Science Museum, South Kensington. With numerous plates and several illustrations in the text. London: John Lane, The Bodley Head. New York: John Lane Company. Toronto: Bell & Cockburn, 1913. 331 pp. Price, $3 net.

Here is a work which does adequate justice to a great man and a great achievement. Although in point of chronology Robert Fulton was an artist first and an engineer afterward, there can be no doubt that in his instinct and sympathies he was first an engineer. Nevertheless, the fact that he was an artist of ability is apt to be overlooked, and in this exhaustive review of his life and work this fact is brought out. Much has been written about Fulton and the "Clermont," but it has been reserved for the assistant keeper of the Science Museum, South Kensington, to gather up and throw into thoroughly collected and readable form all the essential facts related to this subject. The book opens with a sketch of the ancestry, birth and boyhood of Robert Fulton, and speaks of his work as a painter of miniatures, his journey to England, his exhibit at the Royal Academy, and of his turning from the work of an artist to that of a marine engineer and architect. The book tells of his project for marine propulsion, his studies of the English canal system, his digging machine and patent for inclined planes, his correspondence with Lord Stanhope, his arrival in France and his submarine project, and his turning his attention to steam navigation.

This is followed by a sketch of the work of previous experimenters, in which justice is done to the very clever and original work accomplished before Fulton entered the field. Then the story shifts from Paris to England, where Fulton orders a steamboat engine and leaves for the United States. His torpedo experiments are dealt with, and a chapter is devoted to his United States patents, the steamboat monopoly, and the litigation to which it gave rise. The final chapter describes the construction of the first steam man-of-war, and makes reference to the recent Hudson-Fulton celebration. The illustrations are admirable, particularly the reproduction of the original portrait of Fulton by Peale, which is in Independence Hall, Philadelphia, Pa.

HANDBUCH FÜR HEER UND FLOTTE. Enzyklopädie der Kriegswissenschaften und verwandter Gebiete. Herausgegeben von Georg von Alten, Generalleutnant z. D., fortgeführt von Hans von Albert, Hauptmann a. D. Unter Mitwirkung von etwa 400 der bedeutendsten Fachautoritäten. Vollständig in 9 Bänden reichillustrierten Textes mit farbigen Beilagen, Karten, Plänen, Gefechtsskizzen usw. Berlin: Deutsches Verlagshaus Bong & Co., 1914.

These installments of the Handbuch, numbers 69 to 72, are of particular interest to Americans, because they discuss the events in Mexico in a remarkably fine monograph on War (Krieg). The author is General von Falkenhausen. How the army and navy should co-operate is set forth by General von Janson. In the same installments will be found good articles on the "experiences of war," the "war game," and the science of war in general. In view of the present European conflict, one obtains a very good insight into the technical and strategic methods of the Germans in such articles as "*Lager*," "*Landregimenter*," "*Landsknechte*," "*Landsturm*," and "*Landwehr*." Interesting and valuable too are the articles on War Treasures and on the House of Krupp. Numerous maps, tables and drawings will be found scattered throughout the text.

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SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, MARCH 20, 1915

Charles Allen Munn, President
Frederick Converse Beach, Secretary
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All at 361 Broadway, New York

Entered at the Post Office of New York, N. Y
As Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year	$5.00
Scientific American (est. 1845) "	3.00
American Homes and Gardens "	3.00

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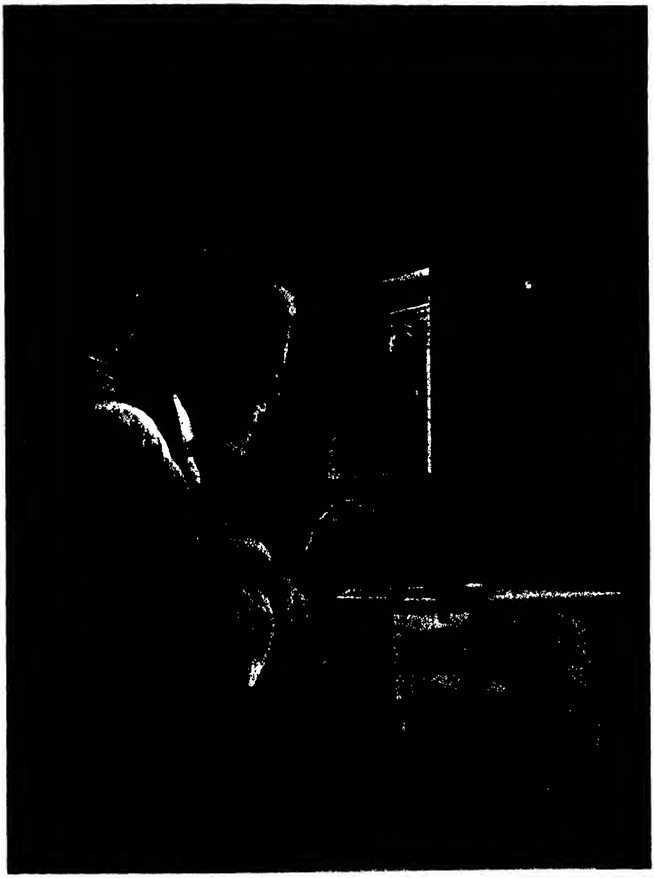
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX NUMBER 2047 | NEW YORK, MARCH 27, 1915 | 10 CENTS A COPY $5.00 A YEAR



SCIENCE AND THE TARIFF

The duty assessed on many kinds of goods by the United States Customs depends on the weight, and this may vary considerably according to the weather. This is the case with cotton yarns, and, without special provisions, the duty levied on the same lot of yarn might easily vary 2 to 4 per cent, according to the weather on the day of entry. To overcome this discrepancy, all yarns are carefully dried until they are in the same condition of dryness. The above illustration shows the electric drying even used, with delicate scales above by which the weighing is done.—[See page 199.]

Recent Evidence for the Existence of the Nucleus Atom*

Varied Theories Developed, but Much is to be Done to Furnish Definite Ideas

By Alfred D. Cole

The great French scientist Poincaré,[1] just before his death two years ago, described an atom before the French Physical Society in these words:

"Each atom is like a kind of solar system where the small negative electrons play the role of planets revolving around the great positive central electron which takes the place of our sun. . . . Besides these captive electrons there are others which are free and subject to the ordinary kinetic laws of gases. The second class are like the comets which circulate from one stellar system to another, establishing thus an exchange of energy between distant systems."

Such an atom is a world in itself and strangely different from the kind we learned about in our text-books 20 years ago. One of the much used chemistries of that day put it in this way:

"An atom is the smallest portion of matter that can exist; it is incomprehensible, indivisible and in itself unchangeable."

How has this great change of view come about? How has the invisible unit evolved into the complex microcosm we now imagine? Time would fail us to trace all the steps of the way; we will attempt only to bring out some of the considerations which have in the past three years led many of our foremost thinkers to believe in that particular type of atom which we may call the nucleus atom. This type is similar to that which Poincaré pictured except that the central body is much smaller—very small indeed as compared with even the minute electrons which circulate about it.

We will recall first several of the discoveries which have forced us to abandon the idea of an indivisible atom. The fundamental one was Sir Joseph Thomson's discovery of the electron. In studying the nature of the cathode rays he found that they consisted of extraordinarily minute particles all exactly alike, whatever the nature of the gas within the tube might be. In a series of brilliant experimental studies he was able to show that the mass of one of these electrons was only one eighteen hundredth that of the lightest known atom. Then came Zeeman's discovery[2] that the separate lines of many spectra are broken up into two or more lines by the action of strong magnetic fields. The study of this effect made it quite certain that light radiation is caused by the rapid vibration of electrons in the luminous body. Therefore, electrons must be present in very many kinds of matter—probably in all. The electrons were early proved to carry a negative charge of electricity. Soon they revealed their presence in a great variety of ways and assisted in the explanation of widely different phenomena. But the corresponding positive constituent of matter proved singularly elusive although most diligently sought for, and it is only very recently that we seem to have traced it to its hiding place.

Different views regarding the nature of this positive constituent have led to much diversity of opinion regarding the structure of atoms. One of the most successful of these theories is that proposed by Sir Joseph Thomson in 1904.[3] He supposed a relatively large positive mass to exist—nearly as large as the atom—with the minute negative electrons distributed through it in such a way as to make the system a stable one. For easy mathematical treatment he assumed the electrons at equal distances apart in a series of concentric circular rings. To secure stability and illustrate certain atomic properties he supposed these rings to be in rotation. Thomson discussed many such configurations and satisfactorily explained many facts regarding the valency, the position in the periodic system, the electropositive or electronegative character and other chemical properties of different substances.

A modification of Thomson's atom was proposed by H. A. Wilson in 1911.[4] He supposes each negative electron to be situated at the center of a positive sphere of sufficient size to neutralize it electrically, and the atom to be made up of a group of such units, the total number being proportional to the atomic weight. In other words, Thomson's one relatively large positive mass is divided up into equal parts, each one containing a single negative electron. The mathematical development of this idea led to the result that the hydrogen atom contains eight such units. The gold atom would therefore contain about sixteen hundred of them.

In the Thomson and Wilson atoms, the positive portion is diffused throughout nearly the whole volume of the atom, a region about one hundred millionth of a centimeter in diameter. This type of structure has accounted for many atomic properties but has not been very successful in explaining the position of the lines in light spectra caused by vibrations in the atom.

I wish to direct your attention to-day more particularly to a type of atom in which the positive charge —equal as before to the sum of the charges of the negative electrons—is highly concentrated at the center of volume of the atom, occupying only an exceedingly small part of the volume. Nagaoka[5] had discussed the stability of such an atom in 1904. Sir Ernest Rutherford revived it in 1911 to explain phenomena observed by Geiger and Marsden,[6] and achieved a striking success. The facts observed were these: when α-rays were allowed to pass through thin sheets of metal, a small proportion of them were observed to be deflected through very large angles. Rutherford[7] made a theoretical examination of the results of a single encounter between an α-particle and an atom of the concentrated-nucleus type, and calculated the proportion of the α-particles which would be deflected through various angles by such encounters. Geiger[8] then made a new experimental study of the scattering produced by gold foil and found a very satisfactory verification of Rutherford's formula. From the amount of scattering at various angles, the value of the nucleus was also calculated. For gold it came out about 100 e. The general conclusion was reached that the nucleus charge is about one half the atomic weight times the charge of an electron. But Barkla[9] had earlier reached the same value for the sum of the electron charges—which in a neutral atom should equal the nucleus charge—by observations on X-rays and the use of a theory developed by J. J. Thomson. According to these views atoms contain only about 1/16 as many electrons as they do on the theory of H. A. Wilson.

On the assumption that large angles of deflection are sometimes due to single encounters with an atom, large forces must be postulated to swing the α-particles so considerably from their paths, forces so large as to require an approach to within an exceedingly small distance from the nucleus center. This distance was calculated to be about 1/3,000 of the atom diameter. If this is true, the nucleus can hardly have a diameter exceeding 1/5,000 that of the atom.

The view that an α-particle may turn through a large angle as the result of a single encounter was strikingly confirmed in 1912 by some remarkable photographs of the paths of α-particles through a gas, taken by C. T. R. Wilson.[10] I have here a reproduction of one of these photographs which shows two abrupt bends in the trail of a particle, one of 10.5 degrees and the other of 43 degrees. This second bend would certainly seem to be a case of "single scattering." The astonishing conclusion regarding the small size of the nucleus has been confirmed by some recent experiments of Marsden[11] in passing α-radiation through a gas.

A theory has been worked out by Darwin that when α-radiation entered hydrogen, a few H atoms would acquire from close encounters with the α-particles a velocity 1.6 times that of the striking α-particle, corresponding to a range four times that of the radiation. Marsden's experiments were undertaken to test this theory. He passes α-rays into hydrogen and observed the scintillations on a zinc sulphide screen placed at various distances. The range of the α-particles was found to be 20 cubic centimeters, but a few scintillations were found when the screen was as much as 90 cubic centimeters distant, due seemingly to the rapidly moving H atoms in their recoil from collision with the heavier α-particles. This was a striking confirmation of Darwin's theoretical calculations. Calculation by his method showed that the centers of the nuclei during collision were not over 1.7×10^{-13} cubic centimeter apart. This then would be the maximum value of the sum of their radii. This is smaller even than the former result and also smaller than the accepted value of the diameter of an electron.

Thus the nucleus of the atom appears to be extraordinarily minute, and this suggests an explanation of the somewhat paradoxical result, that practically all of the mass of the atom seems to reside in the nucleus. For if the size is extremely small its electromagnetic mass would—from the formula $2/3\frac{e^2}{a}$—be relatively large. So its mass might be 1,800 times that of the electron (and J. J. Thomson's experiments suggest that no positive carrier has a mass smaller than that amount) provided its diameter were only 1/1,800 that of the electron. From such consideration Rutherford[12] thinks it probable that the *nucleus of the H atom* is, in fact, the long-sought positive electron.

Attention has been forcibly drawn to the nucleus type of atom within the past year and a half by the extraordinary success it has had as interpreted by Bohr, Darwin and Moseley, in accounting for the exact position of lines in the spectra of gases. Their work has also served to bring into the limelight the earlier and perhaps equally striking work of J. W. Nicholson. In November, 1911, he published a paper[13] in which he assumed the existence of several elements with atoms of very simple and definite structure. One of these he called nebulium. In the neutral condition it was supposed to have a positive nucleus with charge 4 e, and around it at equal distances apart in a circular path, rotated *four electrons* each with a unit charge e. It might, however, lose one electron, when it would become positively charged, its three electrons now taking up new positions a third of a circumference apart. Similarly he supposed that the atom might take up more electrons, and have a negative charge.

He discussed mathematically the vibratory motions of such an atom and showed what kind of a spectrum the radiation would furnish. The theoretical analysis of the spectrum of his imaginary element nebulium showed that all the characteristic nebula lines of the Great Nebula in Orion, leaving out those due to hydrogen and helium, could be attributed to the vibrations of the nebulium atom, except two lines. On the very day he read this paper in England a German astronomer, M. Wolf,[14] presented a paper in Heidelberg which described the discovery that different lines of this nebula were due to radiation from different parts of the nebula, and that these two lines which Nicholson had found exceptional were due to a radiating source different from that of the other lines. Whereas almost all the lines were due to radiation from the bright ring of the nebula, those two lines were caused by radiation from different parts of the nebula, that for one of them coming from the dark central space and for the other chiefly from the outer edge of the ring. All other lines had their maximum brightness in the bright ring itself.

Another imaginary substance, which Nicholson named protofluorine, he succeeded in connecting in a similar way with the spectrum of the sun's corona.[15] This atom he supposes to have—when neutral—a nucleus 5 e with 5 electrons in a circular orbit about it. He analyses its radiation on the assumption that it gives forth radiation energy in quanta, as Planck has supposed. He anticipates Bohr in the emphasis he gives to the idea of constancy of angular momentum in the rotating electrons. His calculations on this protofluorine atom account satisfactorily for the existence of 14 out of 22 lines of the corona spectrum, with an average difference of less than one part in a thousand between observed and calculated values. His calculations also show the magnitude of the positive or negative charge of the atoms originating the various lines. He concludes that in these primitive forms of matter—nebulæ and solar corona—very simple types of atom exist, much more simple doubtless and more amenable to calculation than are the atoms of most terrestrial substances. While the correspondence between his calculated spectra and those observed at Lick Observatory is not so close as is that between theory and observed spectra in the recent work of Bohr, it is important to observe that most of these results are obtained by means of established mechanical principles and without the use of such questionable assumptions as the brilliant young Dane cheerfully and confidently makes.

And now let us consider briefly the work of Bohr. This is set forth in four papers[16] published in the *Philo-*

* Address of the vice-president and chairman of Section B, Physics, of the American Association for the Advancement of Science, at Philadelphia, December 29th, 1914.

[1] Poincaré, Annual Rep. Smithsonian Institution, 1912, p. 199.

[2] P. Zeemann, *Phil. Mag.*, 43, 226-239, 44, 55-60 and 255-259.

[3] J. J. Thomson, *Phil. Mag.*, 7, 237-265, 1904.

[4] H. A. Wilson, *Proc. Amer. Phil. Soc.*, 366 (1911); *Phil. Mag.*, 21, 718 (1911).

[5] Nagaoka, *Phil. Mag.*, 7, 445 (1904).

[6] Geiger and Marsden, *Proc. Roy. Soc. A.*, 82, 495 (1909).

[7] E. Rutherford, *Phil. Mag.*, 21, 669-688 (1911).

[8] H. Geiger, *Proc. Man. Lit. and Phil. Soc.*, 55, Pt. II., p. xx (1911); *Phil. Mag.*, 25, 604-623 (1913).

[9] H. Barkla, *Phil. Mag.*, 21, 648 (1911).

[10] C. T. R. Wilson, *Proc. Roy. Soc. A.*, 87, 277 (1912).

[11] E. Marsden, *Phil. Mag.*, 27, 824-830 (May, 1914).

[12] E. Rutherford, *Phil. Mag.*, 27, 488-498 (March, 1914).

[13] J. W. Nicholson, *Roy. Astron. Soc. M. N.*, 72, 49-64 (1911).

[14] M. Wolf, *Nature*, 89, 70 (March 21st, 1912).

[15] J. W. Nicholson, *Roy. Astron. Soc. M. N.*, 72, 139-150 (1911);

[16] N. Bohr, *Phil. Mag.*, 26, 1-25 (July, 1913); 476-502 (September, 1913); 857-875 (November, 1913); 27, 506-524 (March, 1914).

sophical Magazine between July of last year and March of the present year. He starts with the Rutherford atom, i. e., a minute positive nucleus with its system of electrons revolving about it, the mass of the atom resident chiefly in the nucleus and the number of electrons approximately equal to half the atomic weight. He admits the difficulty of securing stability in such an atom (as compared, for instance, with Thomson's 1904 atom), but thinks that this difficulty can be removed if we admit the insufficiency of the classical dynamics to explain phenomena involving atomic distances, and introduce Planck's quantum into the equations. He claims that this furnishes a basis not only for a theory of atomic constitution but for that of molecules as well. He differs from Nicholson radically in assuming that when in a state of uniform rotation, the electrons do not radiate. This is not in accordance with our ordinary electrodynamics. Each atom, according to Bohr, has a number of "steady states" during which the electrons revolve uniformly and there is no radiation. But in passing from one steady state to another an electron winds inward toward the nucleus with its frequency increasing. Its acceleration meanwhile causes radiation, until the electrons settle into another steady state and cease for the time to radiate. In its stable state the angular momentum of every electron is the same. This agrees with Planck's idea of discontinuous radiation and the amount radiated in one emission for a vibrator of frequency ν is $\tau h\nu$ where τ is some integer and h is Planck's "universal constant." Bohr finds the equation for the relation between the frequency, mass of an electron, charge of electron, τ and τ. When τ is made 2 in the equation, Balmer's series for hydrogen is obtained, and for $\tau=3$ the infra-red series which Ritz anticipated and Paschen found. $\tau=1$ gives a series of lines in the ultra-violet and $\tau=4$ and 5 in the infra-red, neither of which has yet been observed. The lines observed by Fowler and by Pickering he connects with helium instead of with hydrogen.

From this equation he also calculates Rydberg's number N degrees and obtains 3.26×10^{15}. Its observed value is 3.29×10^{15}, so that the agreement of theory with observation is satisfactory. The theory further requires that very low gas density be required for numerous spectrum lines and very great gas volume for sufficient intensity. This probably accounts for the fact that 33 lines of the Balmer series for hydrogen can be seen in celestial spectra while only 12 appear in terrestrial (vacuum-tube) spectra.

From the work of Barkla and of Geiger and Marsden on the scattering of radiation Bohr accepts the view of van der Broek that the number of electrons in an atom in the neutral state indicates the position of the element in the periodic table. Thus he gives hydrogen one electron, helium two, lithium three, beryllium four, etc. The same number expresses the magnitude of the positive charge on the nucleus.

It is difficult to pass upon the validity of some of Bohr's assumptions. So high an authority as Jeans[17] calls it "a most ingenious and suggestive, and I think we must add, convincing explanation of the laws of series spectra," and yet he adds a little later that the only justification for the assumptions Bohr makes is "the very weighty one of success." Rutherford cautiously observes:

"The theories of Bohr are of great interest and importance as a first attempt to construct atoms and molecules and explain their spectra."

The views of Rutherford and Bohr regarding the structure of atoms are strongly supported by some striking experiments of Moseley published during the past year.[18] His works utilize the methods worked out by W. H. and W. L. Bragg[19] for measuring the spectra obtained by reflecting X-rays from the faces of crystals. Barkla and Sadler[20] showed in 1908 that if X-rays from an ordinary tube fall on different metals, "characteristic X-rays" are given off—these being different for each metal. Many metals can give out at least two different types of radiation. Barkla called these the "K series" and the "L series" radiations. For each metal the "K" radiation is about 300 times as penetrating as the "L" radiation. Kaye[21] has shown that an element excited under suitable conditions by rapid cathode rays gives out a considerable portion of the X-rays produced in the form of characteristic rays.

Moseley photographed the spectra obtained by using a great variety of different metals as targets for cathode-ray bombardment. The X-rays so produced were reflected from a crystal face and then fell upon the photographic plate. Spectra of the third order showing fine sharp lines were obtained. Similar results were secured for over 40 metals. For the elements of lower atomic weights, each spectrum showed two prominent lines, and the spectrum of any element was almost exactly like that of the element next below it in the periodic table except that it was shifted in the direction of shorter wave length by about the distance between its two lines. The radiation was of the "K" type. Thus a close relation was established between the X-ray wave-length and chemical properties. Further, the frequency of the principal line was found to be proportional to $(N-a)^2$, where N is an integer and a is a constant equal to about unity. N is called the atomic number of the element. Thus it is 20 for Ca, 22 for Ti, 23 for Va, 24 for Cr, 25 for Mn, 26 for Fe, 27 for Co, 28 for Ni, 29 for Cu, 30 for Zn, etc. These numbers are very nearly in the orders of the increasing atomic weights, but more exactly in the order of Mendeleeff's periodic table. The numbers then correspond with the changes in chemical properties more nearly than do the atomic weights. For instance, we have Fe, Co, Ni representing both the chemical order and order of the atomic numbers (26, 27, 28), while Fe, Ni, Co is the order of increasing atomic weights. It thus appears that this atomic number is a more fundamental quantity than is the atomic weight, or as Soddy[22] has put it,

"It is the nuclear charge rather than the atomic mass, which fixes the position of the element in the Periodic Table."

A. van der Broek[23] had before this suggested that the total number of unit charges on the electrons of an atom is the number representing the position of the element arranged according to increasing atomic weight. But in a neutral atom the sum of the (negative) charges on the electrons should equal the positive charge on the nucleus, so that the two statements amount to the same thing.

When the experimental values found for the frequency were compared with those indicated by Bohr's theory, the agreement was found to be a remarkably close one.

With elements of higher atomic weight Moseley obtained spectra whose lines indicated the Barkla "L type" of radiation. The atomic numbers calculated from the positions of the strongest lines of these "L" spectra ranged from 40 for zirconium to 79 for gold. These experiments then give strong support to the hypothesis of van der Broek that the total charge of the electrons of an atom indicates its position in the periodic system. Known elements were found to correspond with all the numbers from 13 to 79 except three, indicating that three elements probably remain to be discovered. The wave-lengths of the characteristic X-rays from the metal is of the order of 1/1,000 that of visible light (i. e., about 40 waves in 0.000001 inch).

During the past few months Rutherford and Andrade[24] have extended these methods of crystal reflection to the study of radiation from Ra-B Ra-C. The γ-ray spectrum of Ra-B was found to be of the same general type as that of the X-ray spectrum from various heavy metals when bombarded by cathode rays. The result for soft γ-rays from Ra-B shows that its radiation belongs to the "L series" for heavy metals. Moseley's formula applied to the measurement of the lines of the γ-ray spectrum gave $N=82$, which is the atomic number of lead. The atomic weight of Ra-B is, however, 214, while that of lead is 207. This difference is nevertheless fully explained by a new generalization of Soddy and Fajans which we will presently notice. The experiments described in the second paper were made with much more penetrating γ-radiation from both Ra-B and Ra-C. This penetrating γ-radiation from Ra-B was found to correspond to the K series for the same metal, lead. The still more penetrating radiation from Ra-C has a line spectrum of still higher frequency than the K type, for which the name "H" series is suggested. These rays are especially interesting because they have by far the shortest wave-length yet known, only about 1/8 of the wave-length of the shortest X-ray waves measured by Moseley or about 1/80,000 of the wave-length of sodium light. Rutherford in his comments on these waves very justly remarks, "It is surprising that the architecture of the crystals is sufficiently definite to resolve such short waves."

During 1913 some remarkable work on the relations of radioactive substances to each other has given support to the nucleus atom from an unexpected quarter. Fleck,[25] Russell,[26] von Hevesy,[27] Fajans[28] and Soddy[29] have all had a share in this work. They have found that when a radioactive substance ejects an α-particle a substance of different chemical properties and different valency results. The new substance lies two columns to the left in the periodic table, has an atomic number two less and an atomic weight about four less than the parent substance. If, however, the radioactive substance ejects a β-particle or electron, the new substance is one column to the *right* in the periodic table, increases one in atomic number, and does not change in atomic weight. Plainly then two or more elements may occupy the same position in the periodic table, for if an element loses in succession—in any order—two β-particles and one α-particle, its atomic number will be again the same as it was at first. Thus Ra-D has the atomic number 82; it loses a β-particle and becomes Ra-E with atomic number 83; this loses another β-particle and becomes Ra-F with atomic number 84; this finally loses an α-particle and becomes lead, with the original atomic number 82. The series Ur1, UrX1, UrX2 and Ur2 is of the same kind, except that the particles are ejected in the reverse order, α, β, β. So the old difficulty of finding places in the periodic table for the 34 radioactive substances now known has disappeared, since they have but ten different atomic numbers and require therefore but ten places in the periodic table. Soddy has introduced the term isotopes to designate two elements occupying the same place in the table. Isotopes are chemically inseparable and probably have identical spectra, but they have different atomic weights.

It is evident that much remains to be done before we have very definite ideas of the structure of the nucleus atom. Many questions are entirely unanswered. For example, in how many rings do the electrons lie? For hydrogen and helium as for nebulium and proto-fluorine (if they exist) the electrons are so few that they doubtless all lie in one ring, but there are reasons for believing that in atoms of higher atomic weight there are two or more rings. With a large number of electrons present—with the 100 electrons of the gold atom for instance—there may indeed be several configurations which will satisfy the conditions of stability. Even for comparatively light atoms Bohr[30] supposes that as many as five rings exist. Again, from what part of the atom of a radioactive substance do these ejected α- and β-particles come? Soddy[31] believes that both originate in the nucleus, but that the chemical and the electro-chemical properties are controlled by the outer ring of the electrons. Moseley regards the similarity of the X-ray spectra of different metals as satisfactory evidence that such radiation originates inside the atom, while light radiation is determined by the "structure of the surface." Rutherford[32] and Bohr both raise the important question whether atomic nuclei contain electrons, and both conclude that they do. These and many other questions have already been asked but only tentative and provisional answers have thus far been given. Doubtless there is a field here for much important experimental and theoretical work in the immediate future—a field which American physicists will seek to cultivate with their European brethren, who have done about all of the work thus far.

These hasty considerations perhaps suffice to show the varied character of the lines of evidence that have been developed during the past three years to give support to some form of nucleus atom. Radioactive phenomena, X-ray radiation and chemical properties seem to give united testimony for it. Doubtless the final type of atom has not yet been described, for it is easy to criticise the views of Nicholson, of Bohr or any other who has proposed a model, but it is probable that some form of nucleus atom will soon receive general recognition.

Behavior of Incandescent Lamps

In the circular on fees for tests issued by the Bureau of Standards the following facts are stated in relation to the behavior of the films of incandescent lamps:

A normal carbon filament incandescent lamp which operated at constant voltage increases slightly in candle-power for the first 50 hours, more or less, according to the temperature at which it is burned. A stationary period is then reached, after which there is a progressive drop in the candlepower. The initial rise in candle-power is due to a gradual decrease in the resistance of the filament, while the subsequent decrease in candle-power is due chiefly to blackening, caused by a deposit on the inside of the bulb.

This is, in general, the behavior of all incandescent filament lamps, whether carbon, metallized carbon, tantalum, or tungsten. Therefore, in order that a lamp may be useful as a photometric standard it should be carefully seasoned by a preliminary burning sufficient to bring its resistance to a steady state. In order that it may not be affected subsequently by any slight over-voltage, the lamp should be seasoned at a voltage somewhat higher than that at which it is to be used as a standard.

[17] J. H. Jeans, *Report B. A. A. S.*, Birmingham, 1913, 376.

[18] H. G. J. Moseley, *Phil. Mag.*, 26, 1024-34 (1913); 27, 703-713 (1914).

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Watching the Earth Revolve

An Apparatus That Enables the Movements of the Earth to be Directly Studied

By Arthur H. Compton

For most people the fact that the sun rises in the morning, travels slowly across the sky and sets in the evening is sufficient evidence that the earth goes around. Our ancestors, however, believed for the same reason that the sun and moon and stars all actually move across the sky while the earth itself stands still. Indeed, the attempt of Copernicus and Galileo to dispel this idea, which seemed so evident as to be almost axiomatic, was the cause of their bitter persecution. It is really impossible to prove definitely by means of observations on the heavenly bodies whether the earth really revolves while the stars remain fixed or whether it is the stars which revolve about the earth. Even though we may show that these bodies are millions or trillions of miles from us, we can still explain their apparent daily motion by keeping the earth at rest if we suppose that the stars are traveling through the heavens with a sufficiently great speed. *In fact*, this is the assumption on which Ptolemy based his theory of the universe.

It was not until the middle of the last century that Foucault performed his famous pendulum experiment in the Pantheon at Paris (Fig. 1), which was the first good proof that the earth is actually revolving.[1] Even his experiment, however, did not show that all the apparent motion of the stars across the heavens is due to the turning of the earth. Since a pendulum swings in a vertical plane, it is only the part of the earth's rotation about a vertical axis which Foucault's apparatus was able to measure. Suppose that the pendulum is set up at the point O (Fig. 2) on the earth's surface. It is evident that there will be some rotation about the vertical axis OZ, but this will be less rapid than the rotation about an axis OP, parallel to the earth's axis. If the earth turns around the axis $O'P'$ once in 24 hours, there ought to be a rotation about a vertical axis at Paris, whose latitude is 49 degrees, at the rate of once in about 32 hours; and by means of his enormous pendulum Foucault showed that such a rotation actually exists. But the fact that there is such a rotation about the vertical axis does not show what the real angular velocity of the earth is nor the direction of the axis about which the earth turns. For example, a comparatively small rotation about such an axis as $O'M$ would give the same effect on Foucault's pendulum as a much more rapid rotation about the axis $O'P'$. In order to show that all the apparent motion of the stars across the sky is due to the earth's rotation, it is necessary to determine, without observations on the stars, how fast the earth is revolving, and where its axis is located. This requires more data than are given by Foucault's experiment.

[1] This experiment is described in the SCIENTIFIC AMERICAN, February 14th, 1914

By courtesy of the *Illustrated London News.*

Fig. 1.—Foucault's pendulum, which was the first satisfactory means of showing that the earth actually revolves.

If we can measure the rotation about two horizontal axes, OX and OY, as well as about the vertical axis OZ, the earth's rotation will be completely determined. For by combining the rotation about the OX and the OY axes, the rotation about a north and south axis ON can be found, and combining this rotation with that about the vertical axis the true rate of the earth's rotation about OP can be calculated. It is evident that by comparing the relative magnitudes of the rotation about the OX and the OY axes the angle ψ, or the azimuth of the X axis can be obtained, and from the ratio of the rotations about ON and OP the angle ϕ, which is the latitude of the observer, can be determined. Thus, if the rotation about these three axes is measured, not only the length of the day, but also the position of the true north and the latitude can be calculated, and this wholly independent of astronomical observations.

The earth rotation ring shown in the photographs was made for the purpose of measuring these three components of the earth's rotation. The principle on which this apparatus works is comparatively simple. The instrument consists essentially of a circular tube filled with water and mounted on an axis in its own plane, as in Fig. 3. This apparatus is set in a plane perpendicular to the axis OC, about which the earth's rotation is to be measured. If the rotation is in the direction indicated by the solid arrows, it will be seen that the side A of the ring is moving toward the left relative to the other side, and after the ring has been standing a few minutes the water within the tube has the same sort of motion. Now let the ring be quickly turned half way around about its axis, so that the part A comes to the nearer side, as shown by the dotted lines. It is evident that the water in that part of the tube will retain a large part of its original motion toward the left, so that there will be a relative motion between the water and the microscope, which turns with the earth. The speed of this relative motion will of course depend upon how fast the earth is revolving about the

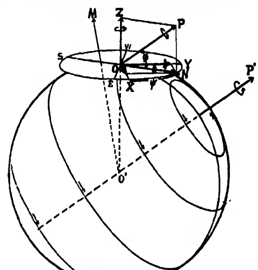


Fig. 2.—Foucault's pendulum was able to measure the earth's rotation only about a vertical axis OZ, while the earth rotation ring measures the rotation about the three axes OX, OY and OZ. The actual length of the day can then be calculated, which was impossible from Foucault's experiment, and the latitude and the position of the true north can also be determined.

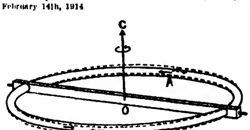


Fig. 3.—If the earth is revolving about the axis OC, when the ring is reversed there is a relative motion between the water and the microscope as shown by the dotted arrows.

Fig. 6.—Measuring the absolute magnitude of the earth's rotation about a vertical axis.

axis OO as well as upon the dimensions of the ring. With the apparatus here described the motion was usually about as fast as that of the minute hand of a watch, and could easily be seen through the microscope.

The ring used in these experiments was made of 1-inch tubing, bent into a circle a foot and a half in diameter. Where the windows were placed the tube was constricted somewhat so as to increase the velocity of the water which was being watched. The motion of the water which filled the tube was made visible by shaking up with it a mixture of coal oil and carbon

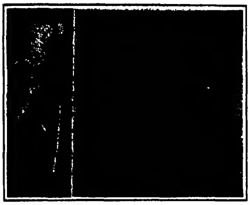


Fig. 4.—Watching the earth revolve. The apparatus is in a constant temperature room just above freezing point to avoid convection currents in the water.

tetrachloride of the same density as water, which formed small suspended globules whose motion was easily visible through the observing microscope. In order to avoid spurious motions due to differences in temperature in different portions of the tube, some parts of the experiment had to be performed with the apparatus boxed up in a cold room, as in Fig. 4, but in measuring the effect due to the vertical component of the earth's rotation, as in Figs. 5 and 6, no such particular precautions had to be taken.

When the ring was held in a vertical plane, as in Fig. 4, the oil globules are always seen to rise on the east side of the tube and go down on the west side, after the ring is reversed. This shows conclusively that the earth is turning over from West to East. Similarly, if the ring is in a horizontal plane, a motion to the left is always observed, which, as we saw above, indicates a motion of the earth in a counter clockwise direction about a vertical axis. It is an interesting experiment to project the motion of the oil globules through the microscopes onto a screen, with the apparatus set up as in Fig. 5. In this manner a room full of people can be shown a moving picture of the earth going around.

As an average of a number of readings, the ratio of the velocity observed about the OY axis to that about the OX axis indicated that the true north was 61.3 degrees from the OX axis, and when the motion about the vertical axis OX was determined, the latitude ϕ was found to be 42.8 degrees. In order to find out from these figures how fast the earth is going around, the apparatus was set up as in Fig. 6, keeping the ring in a horizontal position in order to measure the earth's rotation about a vertical axis. The spectrometer table upon which the apparatus was placed could be turned at any desired speed by means of the driving clock C. First a set of readings was taken with the clock stopped, and the motion of the globules to the left was measured. Then the clock was started, and was so adjusted that the globules moved just as fast toward the right as they had moved before toward the left. It is evident that the spectrometer table was then turning backward twice as fast, relative to the earth, as the earth itself was turning forward. The spectrometer table was turning at the rate of 1.346 times per day, which means that the earth is turning about a vertical axis at the rate of 0.673 revolutions per day. Since the ratio of the rotation about this axis to that about OP was already known, it was easy to calculate that the rate of the earth's rotation about its axis is 0.991 revolutions per day. That is, the length of the day, according to these data is 24 hours and 12 minutes.

It is interesting to compare these values of the azimuth, the latitude and the length of the day with their values as determined astronomically, thus:

	By data from earth rotation ring	By astronomical data
Day	24.2 hours	24.0 hours
Latitude	42.8 degrees	40.4 degrees
Azimuth	61.3 degrees	59.9 degrees

Fig. 5.—The apparatus set up with a projection lantern for showing real moving pictures of the earth's rotation upon a screen.

These figures show conclusively, within the limit of experimental error, that the earth turns about an axis which is identical with its astronomical axis, and that the rate of its rotation is that determined by astronomical observations. Thus it is evident that it is the earth alone which revolves, while the stars remain relatively fixed.

The Koepsel Permeameter*

The moving coil galvanometer and many other electrical instruments built on the same principle consist essentially of a coil of wire suspended in a magnetic field. This coil experiences a torque which is proportional to the product of the current in the coil and the component of the magnetic field in the plane of the coils. In the instruments just mentioned the magnetic field is constant and the current varies. The deflection due to the torque thus becomes a measure of the current strength.

Instead of using a constant magnetic field, we may maintain a constant electric current through the moving coil and use this system for the measurement of the magnetic field. If this magnetic field is due to an electromagnet, the magnitude of the field depends upon the magnetomotive force applied and the material of the magnetic circuit. An electromagnetic system of this kind may therefore be made the basis of an apparatus for the determination of the magnetic properties of iron and steel.

Robinson[1] in the *Electrical World* of February 24th, 1894, gave a complete description of a permeameter based on this principle. However, he had not actually built the instrument.

Three days later Koepsel[2] described before a German electrotechnical society substantially the same piece of apparatus, which he had built and was actually using. This apparatus, as later improved by Kath,[3] is widely used, both in this country and abroad. It is sometimes called the Siemens and Halske permeameter, from the name of the manufacturer.

Orlich[4] at the Reichsanstalt determined a number of hysteresis loops with the Koepsel instrument and also by the magnetometer method, using ellipsoidal specimens for this latter test. His data show that at inductions of 15,000 gausses the instrument gives values of the magnetising force which are too high. All values of the coercive force, as obtained by this instrument, are greater than those of the magnetometer. The shearing curves differ for different materials. Rohr[5] compares hysteresis data obtained by the Koepsel permeameter with that obtained by the watt-meter method and finds that the values of the Steinmetz coefficient thus obtained are in substantial agreement.

Much of the data on the magnetic properties of iron and steel have been determined with this apparatus. It seems, therefore, well worth while to give the Koepsel permeameter a careful experimental examination with a view to determining its reliability for use in making magnetic measurements.

As a result of the experiments conducted, the following conclusions were drawn:

The Koepsel permeameter has several valuable characteristics. It gives direct readings of the magnetizing force and the magnetic induction, both for normal induction and for hysteresis data. It is easy of manipulation and does not require greater care than the usual deflection instruments. It repeats its readings as consistently as could be desired. The readings may be very useful in indicating relative values of different materials or the degree of non-uniformity of similar materials. The fact that the observed values of the magnetizing force may differ by as much as 100 per cent from the true values does not destroy the value of this instrument for purposes of comparison.

From the experimental consideration of the different factors which may affect the accuracy of the readings the following detailed conclusions were drawn:

1. Readings on the two sides of the zero of the instrument may differ considerably, but the mean of the two values thus obtained shows satisfactory consistency on repetition.

2. Shearing curves for different grades of material show that the correction to be applied to the observed magnetizing force is not constant for a given induction, but depends upon the nature of the test specimen. This correction is usually subtractive for points below the knee of the induction curve and additive for points above the knee.

3. An increase in the cross-section of the test specimen tends to increase the observed values of the magnetizing force for points below the knee of the induction curve, and to decrease the observed values for points above the knee.

4. The length of the specimen projecting beyond the yokes produces no noticeable effect for points below the knee of the induction curve. For points above the knee the projecting ends increase the observed value of the magnetizing force.

5. If the bushings are not pushed all the way into their proper position, a higher apparent value of the magnetizing force is observed, due to the increased length of the portion of the bar under test.

6. Hysteresis loops obtained by the Koepsel permeameter always show a low observed residual induction and a high observed coercive force.

7. A theoretical and experimental study of the distribution of the magnetic fluxes through different parts of the magnetic circuit shows that shearing curves of the form observed are to be expected.

If the apparatus is to be used for the determination of the absolute values of the magnetic quantities, it is necessary to apply a correction to the readings. Since the apparatus gives consistent results on repetition, the whole error may be charged to errors in the correction or shearing curves. As this shearing curve varies with the dimensions and quality of the specimen, it is essential that shearing curves be prepared for each size and quality of specimen to be tested. With extreme care and the use of proper shearing curves, the apparatus is capable of giving quantitive results within 5 per cent of the true value of the magnetizing force for a given induction.

Uncorrected hysteresis data for hard steels show values of the residual induction that are too small; the error may be as great as 10 per cent. Values obtained of the coercive force are systematically too large; the error may be as much as 40 per cent.

* A brief summary of Bulletin 228, issued by the Bureau of Standards, describing an investigation made by Charles W. Burrows, Associate Physicist.

[1] L. T. Robinson: "A Modified Instrument for the Determination of B-H Curves," *Electrical World*, 23, p. 236, February 24th, 1894.

[2] A. Koepsel: Apparat zur Bestimmung der magnetischen Eigenschaften des Eisens in absoluten Mass und directer Ablesung, E T Z, 15 p. 214, April 19th, 1894.

[3] H. Kath: E T Z, 19, pp. 411-415, 1898.

[4] E. Orlich: E T Z., 19, pp. 391-394, 1898.

[5] W. Rohr: E T Z, 19, p. 718, 1898.

Petroleum Conditions in Russia

The report of the United States Geological Survey on the Production of Petroleum in 1913 contains the following statement:

The declining condition of the older Russian petroleum localities noted in the previous reports of this series continued in 1913. It was not compensated by increase in the new districts, which include Emba for the first time as a commercial factor. The outlook for the future of Russian production is brightened by the prospecting which has progressed rapidly in the Ural-Caspian region, north of Gurief. The field is reached by steamers to the north shore of the Caspian Sea. About thirty miles from the shore large wells have already been obtained at Dossor, and pipe lines are laid to Gurief, where barges can be loaded and then towed up the Volga without the reloading which is necessary with shipments from Baku. Oil from Baku destined for the Volga River trade arrives at Astrakhan in steamers too deep for the river and is then transferred to barges. Exploration in this Ural-Caspian field has been extended many miles north of the present developments. Prospecting is impracticable in winter, but in summer it can be prosecuted with success in spite of the lack of water, the available supply of which is derived principally from snow scraped up in winter and stored in pits. The inhabitants of the region are nomads living in tents. They are peaceful and disposed to aid exploration.

The Economies of Home Lighting

Facts and Figures on Various Systems, Past and Present

By Reginald Trautschold

Everybody is interested in lighting, for no matter how humble home may be, lighting of some description is necessary. The progress made in the art of artificial illumination is familiar in a general way to all, but it is very questionable whether many are familiar with the economic aspects of this progress. Is lighting being more efficiently—economically—performed than it was 50 years or more back? Have the economics of the subject kept pace with the gains in convenience and facilities, or have these advantages been secured only at increased cost of lighting?

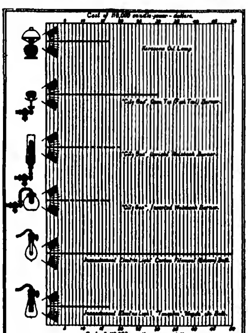
To arrive at a logical understanding of the efficiency of various systems of lighting a basis of comparison is necessary, calling for a unit of light measurement. The recognized unit is a candle-power per hour—not the ordinary candle that is procured at one's grocer, but an arbitrary unit, originally the light emitted by a spermaceti candle burning 120 grains per hour, known as the British standard candle, but later modified to the "International Candle" which emits slightly less light than the British candle. In the days when the kerosene oil lamp was about the best available source of light, the candle-power was not the term in which it was customary for the housekeeper to measure illumination, the measure in those days was far more apt to be the length of time that a five gallon can of oil would last. It was not until the advent of the electric light that the term candle-power came into general use. The 16 candle-power incandescent electric light bulb—the 16 candle-power Edison—then became the popular measure of comparison, but this, by the way, is far less reliable than the five gallon oil can measure, for a 16 candle-power electric light bulb does not emit 16 candle-power, rarely over 12 and frequently nearer 10. The five gallon oil can is capable of giving out 4,500 candle-power, if waste can be eliminated, and with any care at all the losses from a five gallon can should be very much less than 5 quarts, so that the five gallon oil measure for light is really more accurate and reliable than a measure based on the lighting capacity of an ordinary carbon filament electric bulb—the common type of electric light—taken at its rating. The housekeeper is now familiar with the term candle-power, but is almost as much in the dark as formerly as to its true meaning.

A candle-power is really such a small unit that a comparison of lighting costs based on it, though scientifically interesting, fails to impress any but the economist. Some concrete and larger unit presents facts so much more forcibly and clearly. For instance, the cost of lighting a small cottage or flat for a year forms a very much more understandable comparison. Taking the average year in and year out, such an establishment—if the hall light is turned down low, the kitchen light extinguished when the last dish of the day has been washed and put away and all the other little economies that are insisted upon by the careful housekeeper—would burn an equivalent of about 100 candle-power 3 hours each day, or 110,000 candle-power during the year, illumination that would not be very excessive for one fairly large room.

In the days of the kerosene lamp, the five gallon oil can would have to be replenished every two weeks or so. In such an establishment, for about 125 gallons of kerosene would be consumed during the year. Not to exceed this amount, the oil would have to be handled with great care—avoiding unnecessary waste—and the various lamps supplied at all times with clean clear glass chimneys and be devoid of all such light absorbing devices as shades. Such unattractive lamps would shock the artistic sense of even the most frugal householder, and the housekeeper would insist upon the use of shades for most, if not all, of the lamps, and this, even if discrimination was used to employ only fairly transparent shades, would mean about two more fillings of the five gallon can during the year. In days that have past, kerosene was cheaper than it is now, but if a fair comparison of the cost of lamp lighting is to be made with more modern lighting systems the average price of lamp oil to-day—about 12 cents per gallon—must be considered. If the original cost of the lamps be disregarded, the maintenance expenses for chimneys, wicks and so forth be overlooked, as well as that for the labor entailed in cleaning, refilling and caring for the lamps, the yearly cost of lamp lighting would be, if shades were not employed, about $15.00 a year, or, with shades, about $17.00. This latter figure may then be taken as about the yearly cost of kerosene lamp lighting for an establishment requiring 110,000 candle-power.

Ever since "city gas" first came into general use for lighting, the type of burner most commonly employed has been the ordinary open tip ("fish tail") burner, emitting a fan-like flame. Such a burner has a lighting capacity of about 20 candle-power, and to obtain 110,000 candle-power about 27,000 cubic feet of gas would have to be burned, or at least paid for, as there is bound to be a certain unavoidable leakage. This quantity would demand the use of unshaded lights only, for shades would, as in the case of oil lamps, lead to extra expense. Though shades are not deemed as necessary for gas as for oil lamps, some such extra expense, for the sake of "looks," would surely be incurred, so another 3,000 cubic feet of gas would be a conservative amount to add; and this would mean, at the average price of "city gas," about $1.00 per thousand cubic feet, a lighting bill of $30.

By substituting the more cleanly and convenient gas for oil lamps, the annual lighting charge would be very nearly doubled. The difference in cost of the two systems would go a long way toward paying for broken lamp chimneys, new wicks and to recompense the housekeeper for the extra work entailed in caring for the lamps. Civilization was not to be denied, however, so the housekeepers were finally prevailed upon to realize the wisdom of spending nearly twice the money they had been accustomed to spend for lighting for the privilege of evading some irksome and, it must be admitted, some disagreeable work.



Whether the thriftiness of some good housewives and their disinclination to abandon the more economical system of lighting for the more convenient was the cause, or natural progress, it was not very long before the Welsbach burner was developed. The first of those burners, and that still most generally encountered, was of the upright type, consisting of a mantel of such fragile material, unfortunately, that a protecting chimney is necessary. This burner is very much more economical in the consumption of gas than the open tip burner for the same illumination, consuming only about one-third as much gas. The annual cost of illumination—110,000 candle-power—would then be, with "city gas" at $1.00 per thousand cubic feet, about $10.00, less than two-thirds as much as that of oil lamp lighting. Unfortunately, the full benefits of this system of lighting have never been realized and probably never will be. The full value of light is not properly comprehended and the temptation of using more light and still more is too great for the majority to resist, particularly when little or no more effort is necessary to secure it and the extravagance only becomes apparent when the light bill is presented for payment. When the light bill is smaller than it was formerly—open tip burners probably having preceded the Welsbachs—it is still more difficult to realize that economy in the use of light has not been what it should. In an establishment where Welsbachs can be used, provision is also adequate for open gas tip burners, so that if the same economy is to be observed in the use of light, only the equivalent of one-third as many Welsbachs should be used as open tip burners. For economy, only certain burners in the establishment should be generally used and the use of all others prohibited; but always some of these forbidden burners are so conveniently located that the good resolutions are not kept. Still another reason for failure to realize the full economies of the Welsbach is that the mantels are fragile and liable to destruction and the chimneys will break or crack; so that unless a supply of extra mantels and chimneys is kept on hand, a temporary return to the open tip burners becomes necessary, with the accompanying consumption of three times the amount of gas, if the same degree of illumination is to be secured. The lighting bill when employing upright Welsbachs is, therefore, very much more likely to be about $20.00 than $10.00. Even at $20.00 per year, the saving of the Welsbach system would mean the cutting down of the gas bill for open tip burners to two-thirds, less than 20 per cent more expensive than lighting by lamp.

The upright Welsbach is not the most sparing in the use of gas, however. The inverted Welsbach mantel being even more economical, due to the more efficient mixing of gas and air before it is ignited. This type of burner consumes but about one-fifth as much gas as does the open tip burner, so that, if its full economic value could be realized, the expense for 110,000 candle-power would be but $6.00. The same drawbacks that prevent the realization of the full value of the upright Welsbach apply with equal force to the more efficient inverted burner, so that it is doubtful if their use would cut the annual gas bill much below $16.00 or $17.00. At such rate, all the benefits and advantages of gas lighting may be gained and many of the disadvantages of the oil lamp evaded, with a lighting bill no greater than that required for the use of oil lamps.

Disadvantages that are possessed by gas lighting as well as by kerosene lamps are that matches or other means of ignition are required; while giving out light they also give out considerable heat; and they consume much of the oxygen of the air while burning, a decided disadvantage in the present hygienic age. These disadvantages have made possible the great inroads of electricity into the domain of lighting. For domestic purposes the incandescent electric bulb is almost universally used, and, until recent years, this meant the common carbon filament lamp—the Edison lamp. These lamps are made in various sizes, capable of emitting a definite amount of light—the usual *rated* candle-power being 16 and multiples of 16. The average consumption of electrical energy by such lamps, with clear glass bulbs, is very close to four and one-third watts for each *actual* candle-power, so that for 110,000 candle-power about 475 kilowatts (1 kilowatt = 1,000 watts) would be required. As some shades or frosted bulbs would very probably be used in any private apartment or house, a more conservative figure would be 500 kilowatts. At 10 cents per kilowatt—the average rate charged by electric light companies for such small amounts of current—this would make a lighting bill of about $50.00 a year, 66 2/3 per cent more expensive than gas lighting with open tip burners and nearly three times as expensive as lighting by kerosene lamps. Decided advantages are realized by such a system of lighting, it is true, but only at the cost of considerable expense.

In the last few years there have been put on the market several electric light bulbs that are very much more economical in the consumption of electricity than the carbon filament bulbs—bulbs in which the carbon filament is replaced by fine wires of a metal that becomes incandescent more easily than the carbon filament. These bulbs, known under various trade names, such as "Tungsten" and "Mazda," consume but about one and one-third watts for each *actual* candle-power, instead of nearly four and one-third as do the carbon filament bulbs. Naturally, these more efficient bulbs greatly reduce the cost of electric lighting, so that by their use the lighting bill for 110,000 candle-power is reduced to from $50.00 to $17.50, very close to the amount that would be required for securing the same amount of light from oil lamps. This is about the latest thing in the way of electric lighting and at the present time cannot be very much bettered unless the price of electricity can be brought below 10 cents per kilowatt.

It is curious to note that each advance in the art of lighting, introduction of a more convenient and it may be assumed more efficient system, has created a very material increase in the cost of lighting, as heavy payment was demanded for each added convenience; and progress and improvement in the various lighting systems have as yet been unable to better the cost of lighting under the old kerosene oil lamp system. What future progress will

bring about is difficult to say, but it will in all probabilities be a marked reduction in the cost of electric lighting, the conveniences, safety and hygienic advantages of which system makes it superior to all others.

It is a well known and generally admitted fact, that it would be quite possible to use "city gas," at its present price, in a gas engine by which a lighting dynamo could be driven and supply current well under half the price now being charged for electricity by the large public service companies. Such practice would be entirely out of the question for each individual habitation, or any but a large establishment, on account of the comparatively high cost of initial installation and the impossibility of securing the necessary attendance at any price commensurate with the value of the electrical output. Such a scheme would be quite feasible, however, for a group of consumers or a community in which the demand for light was fairly uniform and constant, but even under such favorable conditions the experiment would hardly be a wise one, as still more economical results could be obtained through the use of oil engines in place of a gas engine operating on "city gas."

At the present price of kerosene, the fuel expense for an oil engine using such power medium would be but about 2 cents per kilowatt electrical output, or, if crude or fuel oil was used, this would be cut down to 1 cent, or less, for each kilowatt delivered by the electric light dynamo. Electric light rates commensurate with such fuel expenses could only be realized in cases where the demands for current were pretty uniform and constant during certain fixed hours of the day and no current required during the balance of the twenty-four—the reason that the public service companies find it necessary to charge such an apparently exorbitant rate as 10 cents per kilowatt. This will necessitate comparatively small communal lighting plants operated on a co-operative basis, for only by such means can the true economy of the efficient, convenient and altogether desirable electric light be furnished to the public at a price anywhere near that which the cost of production should command.

The future source of light may again be from the "oil can," but instead of burning the oil, as in the old days, the more efficient method of exploding it in an engine will be resorted to.

Science and the Tariff

Delicate Apparatus Employed in Determining Customs Duties

By Dr. E. E. Pickrell

But few people are aware that science is a valuable assistant to "Uncle Sam" in the enforcement of the tariff laws in ascertaining the duties on imported merchandise, and that the application of every new tariff is more dependent on science. How many persons realize, when they purchase an article made wholly, or in part, of imported cotton yarn, or cloth, that the United States Government, in collecting the duties on that article, took into consideration the fact that cotton yarn and cloth are hygroscopic, and the amount of moisture they contain is dependent upon the temperature and relative humidity of the atmosphere? But few have a knowledge that in the administration of the cotton schedule of the tariff act of October 3d, 1913, the U. S. Treasury Department has taken into consideration the moisture content of cotton yarn and fabric. Schedule I (otherwise known as the cotton schedule) of this act provides for cotton yarn and fabric at an *ad valorem* rate of duty and establishes the lines of demarkations of the various classifications, according to the yarn number.

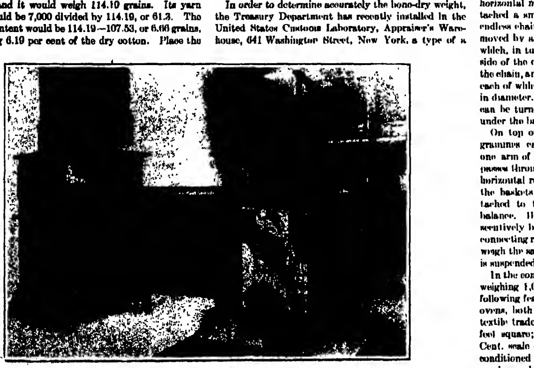
In the ascertainment of the yarn number the weight of the yarn, or cloth, is one of the principal factors. The moisture content, therefore, bears an important relation to the weight, and consequently to the yarn number. The quantity of moisture cotton cloth or yarn contains depends upon the temperature and relative humidity of the atmosphere. As an illustration, let us take a sample of 840 yards of cotton yarn, which under atmospheric conditions of 70 deg. Fahr. temperature and 65 per cent relative humidity, weighs 116.67 grains. The yarn number of this sample is 60, for a No. 1 cotton yarn is a yarn 840 yards of which, under these atmospheric conditions, weighs 1 pound, or 7,000 grains, and a No. 60 cotton yarn weighs 1/60 of 7,000 grains, or 116.67 grains. In this sample the proportion of moisture to dry cotton is as 8½ parts to 100 parts, or 9.14 grains to 107.53 grains.

Expose this sample for a sufficient period of time to an atmosphere of 73 deg. Fahr. and 46 per cent relative humidity, and it would weigh 114.19 grains. Its yarn number would be 7,000 divided by 114.19, or 61.3. The moisture content would be 114.19—107.53, or 6.66 grains, representing 6.19 per cent of the dry cotton. Place the same sample in an atmosphere where the thermometer reads 68 deg. Fahr. and the hygrometer records 97 per cent, and its weight would be increased by 121.95 grains, which is equivalent to a yarn number of 57.4. The moisture content would be 121.95 - 107.53, or 14.42 grains, which represented in percentage of the dry cotton contained in the sample, is 13.41. It is therefore, quite apparent that a few degrees in temperature and a variation in the relative humidity has an appreciable effect upon the weight of cotton yarn, and yarn number.

If, on the day of importation of a consignment of cotton yarn into the port of New York, the thermometer registered 73 degrees and the hygrometer returned a reading of 46 per cent, its yarn number, as ascertained, would be 61.3, and the merchandise, accordingly, classified under paragraph 250 of the tariff act as cotton yarn exceeding 50s to 70s at 22½ per cent *ad valorem*. But, provided the temperature and humidity had been 68 degrees and 97 per cent, respectively, the yarn number would necessarily have been 57.4, and in the classification of the importation, a rate of duty of 20 per cent *ad valorem* would have been assessed as for cotton yarn exceeding 40s to 50s. To avoid these differences of classification and assessment of customs duties on cotton yarn and cloth, due to variations in the atmospheric conditions, the Treasury Department has declared that "whenever the weight is found within 5 per cent of its given equivalent weight in the table it will be necessary to make further trials of at least four samples, and if the average weight is again found to be under 5 per cent, the sample must be conditioned; that is, dried to bone dryness, and a regain of 8½ per cent added back."

Bone dryness of the cotton yarn, or cloth, is a condition in which all moisture is expelled, and this is only accomplished by dryness to a constant weight in a circulating atmosphere at a temperature of 110 deg. Cent. The regain of 8½ per cent added to the bone-dry weight would give the weight of the cotton yarn, or cloth, as if it had been subjected to an atmospheric condition of 70 deg. Fahr. temperature and 65 per cent humidity.

In order to determine accurately the bone-dry weight, the Treasury Department has recently installed in the United States Customs Laboratory, Appraiser's Warehouse, 641 Washington Street, New York, a type of a machine known as the Freas electric-conditioning oven.



The oven has a one-fifteenth horse-power motor connected by a belt with the fan which maintains a circulating atmosphere within the oven.

The oven is built of heavy fireproof asbestos wool, with chamber size 12 inches by 12 inches by 12 inches. Two small electric lights are placed in the upper inside corners of the chamber, and can be turned on or off by a switch-button on the front of the oven above the door. One of the lights is continuous, and serves as a source of illumination for the oven, and the other is intermittent, and indicates the making and breaking of the contact of the heat regulator.

To expedite the drying, the circulation of heated air supplied to the oven is artificially adjusted by means of a fan situated in the back of the chamber, and driven by a 1/15 horse-power motor, shunt wound, with a speed of 1,100, and a voltage of 110. Complete ventilation, to get rid of the moisture from the substance being dried, is obtained by two openings, or vents, one on each side of the back of the oven next to the bottom; these openings can be closed, or partially closed, by means of metal plates which fit over the openings, and are readily turned.

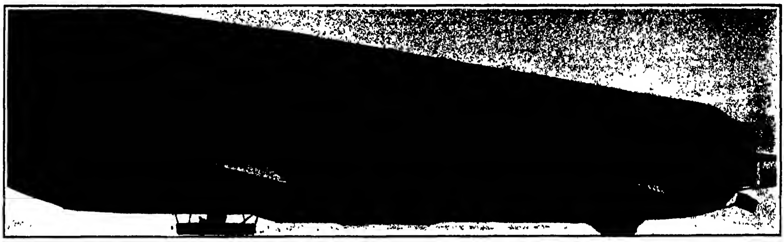
The heating element, which is wound with a high heat-resisting wire, is situated in the bottom of the chamber underneath a fire-clay plate which contains numerous holes for transmission of heat. The regulation device is fitted in a separate compartment made entirely of metal, and located above the chamber. Its action depends on the expansion of the metal tube through the chamber, operating a lever, which makes and breaks a contact, with proper means to prevent arcing. The lever is extended to serve as an indicator, operating up and down a graduated scale on the outside of the oven. The indicator is moved to the desired temperature by simply turning the knob screw at the bottom of the scale.

The oven is also provided with a double window (mica on inside and glass on outside), with drop shield, on the side of the oven, so as to permit operator to manipulate the horizontal rod with fastened hook for removing and returning baskets from carrier to connecting rod attached to one arm of the balance.

To the top of the chamber is fastened a four-armed horizontal metal frame. At the end of each arm is attached a small pulley, and on these pulleys moves an endless chain, similar to a bicycle chain. This chain is moved by a toothed wheel on the side of the chamber, which, in turn, is moved by a thumb-screw on the outside of the oven. Ten metal hooks are suspended from the chain, and to these are swung ten metal mesh baskets, each of which is 6 centimeters in depth by 4 centimeters in diameter. By the aid of the thumb-screw, the carrier can be turned, so as to bring the baskets into position under the balance to be weighed within the oven.

On top of the oven is an analytical balance of 100 grammes capacity and 1/10 milligramme sensibility, one arm of which is attached to a connecting rod which passes through an orifice into the oven. By turning the horizontal rod which traverses the rear of the chamber, the baskets can be removed from the carrier and attached to the connecting rod which passes into the balance. By moving the carrier the baskets can consecutively be brought into position and attached to the connecting rod. All the baskets are adjusted so that they weigh the same, and are equal to the counterpoise which is suspended from the other arm of the balance.

In the conditioning of the samples of yarns and fabrics weighing 1,000 grains and less, this oven possesses the following features that are superior to other conditioning ovens, both electric and gas, that are now used in the textile trade: (1) It occupies a small space, about three feet square; (2) a constant temperature within 1 deg. Cent. scale can be maintained; (3) ten samples can be conditioned at one time; (4) an analytical balance with a maximum load of 100 grammes and 1/10 milligramme sensibility can be used for weighing the samples within the oven.



The "Viktoria Luise" was formerly a Zeppelin passenger airship, but is now a war craft attached to the German navy, known as "LZ-II." She was completed in 1912, is 488 feet long, with a gas capacity of 664,000 cubic feet.

The forward car carries propelling engines, the pilot, and observers. The rear car also carries propelling engines and engines for supplying electric lighting. These cars are connected by a gangway with the central cabin, which has a considerable carrying capacity. These vessels usually travel at a height of 8,000 feet, to avoid anti-aircraft guns. The greatest height reached by a Zeppelin is 10,400 feet, and it required an hour to reach that elevation.

An Airship in the Field*

A Personal Narrative from a German Observer

"Up to now the airship branch of the [German] military service has been particularly silent concerning its doings, but there is no doubt that it will perform a tremendous work against the enemy. There is good ground for belief in the effectiveness of this weapon, in which—even our enemies acknowledge it—German energy and thoroughness have surpassed all opponents. Although England and Russia completely, and the French in a slightly lesser form, denied the utility of these air-cruisers, claiming that they could easily be put out of action, yet to-day they undoubtedly sail over the lines and fortresses of the enemy. In spite of their size and the slowness of their flight they are less vulnerable than the aeroplanes, because even many hits and the loss of several people does not essentially damage the great airship unless under exceptional circumstances.

"The account of a long journey was related by a German airship officer to an Austrian reporter at the time of the first great battle on Polish ground. 'We were 13 hours on the way, doing 700 kilometers, of which 500 kilometers was over the enemy's country. It was still dark when my man woke me in the morning. In an hour's time we had sighted B – , while 2 hours later we crossed the frontier. We went at 2,000 meters. Czenstochowo lay outlined below us; the Warta twisted in its marshy course among the hills. For 100 kilometers we followed the railway to Kielce, and saw soldiers marching along half of the distance under us who were either Russians or Austrians. We threw down friendly greetings and turned to the north-east, the railway showing us the way. The forts of Ivangorod lay like small four-cornered cubes round the fortress; we turned away from them. The heights of Radom were crowded with soldiers. It was obvious that the Russians were in strong force and were prepared to receive the enemy.

"'Our appearance created huge excitement among the great gray patches below, which were the regiments; thousands of white gunpowder smoke came puffing, only visible by the telescope. Near Lublin there was firing from large masses of troops, who covered the whole level plain to the horizon. South-east of Lublin infantry was forming, quite visible though small, with artillery in front. The smoke from the cannon rolled itself into a ball, and for the first time we heard through the noise of our own motor the detonation, though very faint and far off. I was in the back gondola; it sounded like the rapping of one's knuckles against a wall. Then, again, right under my feet, the bullets hit but recoiled harmlessly from the metal covering of the gondola. Then a bullet went by my ear, into the outer covering of the balloon which hung over our heads like a gigantic silver roof, bored a tiny hole in it, ripped a strip of the inner lining, and lost itself in the hydrogen.

"'Bullet now followed fast on bullet; we counted twenty-five hits, twenty-five holes through which the gas escaped, also the shells came nearer, a splinter fell in our gondola like a stone. A telegraph message came from the front gondola, "Full speed!" All four motors drove. Then came the order to patch what needed patching. Swinging between heaven and earth we repaired what was possible to repair. As the sun was sinking we landed among the vanguard of our friends, gave our report, journeyed on again, and ended in the Austrian headquarters.'

"So much for the information-gathering journey. Originally the idea had been to cause destruction to fortified places, but now it has also been found possible to be useful against the armies in the field. As to its effect on towns, we know a great deal from actual witnesses in the bombarded towns. Liege, Namur, and Antwerp were the first towns to make acquaintance with the fear of the air, and undoubtedly the moral impression of these visits hastened the surrender of all these towns."

A citizen of Antwerp relates the following: "I was awakened at 1 o'clock by the tremendous humming of a motor. It came from above. I opened the window and saw to the south over the railway station a gigantic being, which threw a stream of light on the town. Then followed a noise like muffled bells and a clap of thunder. Again a stream of light, and two seconds later a sound as if two goods wagons had crashed against one another with terrific force. Then followed, thundering from the guns of the forts, rifle-fire, and between them the bombs of the German airships. The inhabitants all streamed into the streets, men, women, and children, in their night clothes, wandering from one corner to another, seeking safety, for at first the people thought the bombardment of the city had begun.

"That was the beginning. Since then the methods and the weapons of the airships have been necessarily perfected till the early work seems mere child's play compared with the destructive power of the present weapons. For example, at the visit over Ostend, while it was still in the hands of the English, the projectiles produced frightful destruction. 'It was,' so writes the Antwerp *Metropole*, 'a quarter to twelve at night, while Ostend lay in the deepest darkness, that a telephonic message from Thourout informed the commandant that a Zeppelin was passing in the direction of Ostend, and a few minutes later one could hear the fearful hum of its engines, 200 meters above the roofs.' (The witness was deceived over the real flying height of the airship, but the night is naturally not good for such observations.)

"The Zeppelin turned its searchlight on the sea coast, then took the direction of the railway station, and soon four fearful detonations tore the stillness of the night. The citizen guard of Ghent, who were occupying the station, fired twice with the guns, but with the swiftness of the wind the airship disappeared into the night. The first bomb had torn a hole in the Bois de Boulogne more than 32 feet in circumference and 16 feet deep. The others had produced 'fantastic destruction' near the station, but had not actually hit it. Fitted out with more machine guns the Zeppelins are also unpleasant opponents for the troops."

*This narrative and the accompanying illustrations are derived from *The Sphere*, London.

Damascus Blades*

As just now weapons of all sorts have more interest than usual for most of us, perhaps the following, which appeared a good many years ago as an appendix to Captain Abbot's journey to Khiva, may be of service. It was a translation by Captain Abbot of a paper written by Colonel Anossof, a well-known manufacturer at Zlatoust, in Siberia, and as it deals entirely with an art of the past, is not at all out of date.

In Russia we understand by the damask, a metal harder, and supplying a material for arms of keener edge than ordinary steel.

The original country of the damask is the East, and there is reason to think that its properties were even less understood in other countries of Europe than in Russia.

All the researches of chemists have, until now, failed of discovering any essential difference between the damask and ordinary steel, which, nevertheless, proves only that the analysis has been imperfect. Although the chemists of the present day presume that the natural damask is the effect of a crystallization, produced by retarded cooling of the heated metal; yet, not having the means of producing a damask equal to the ancient work of Asia, they cannot establish this ground; although they have before their eyes the laws of crystallization discovered by the mineralogist Haüy.

If crystallization generally is but the result of the structure of bodies, under certain physical considerations, the question follows, wherefore in the damask is it not the result of a similar cause; and as common steel acquires no visible damask by gradual refrigeration, is not this a convincing proof that the composition of damask differs from that of ordinary steel? If chemical analysis fails to discover that difference, we can only conclude that it answers not its end. The researches of metallurgists and of artificers, who have been at pains to make the damasks, and to inform themselves of the ancient art, have made no decisive progress. I have seen no damask of superior quality wrought in Europe; and that which has been written upon the subject gives no sufficient light; for I have found in no treatise upon the damask any provision for perfecting the steel. Thus, on one hand, the imperfection of our chemical knowledge, and on the other, the difficulty of fabricating the damask, leave Europeans still in uncertainty as to its merits. Many scientific men, relying upon chemical analysis, refuse credence to the superior qualities of the damask; while amateurs, who have any knowledge of the subject, set as great value upon it as do the people of the East, and willingly pay £80 and upwards for the best damask blade.

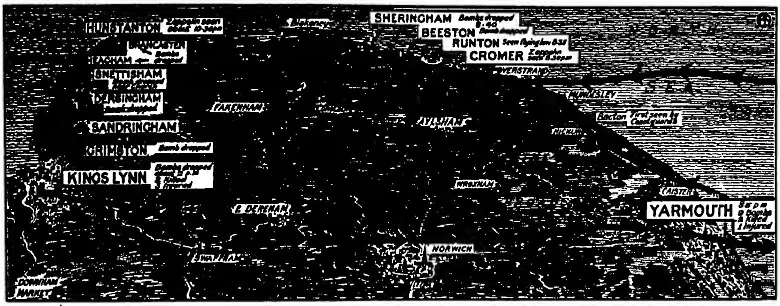
Time out of mind the damask has been used in Asia; and to this day it has lost nothing in price. Nevertheless, the Orientals, although less advanced in knowledge than ourselves, could not be deceived throughout the course of ages, upon the merits of objects purchased only at a very high price.

All steel which exhibits a surface figured with dark lines is called damask.

In some of the various kinds of steel these figures appear immediately after burnishing; while in others dilute acid is necessary to bring them out. The juices of plants and ordinary vinegar suffice for this effect. The process of bringing out the figures of steel is called corrosion.

The damascene which appears upon the surface of

* From the *English Mechanic*.



How the German air attack on the east coast of England was carried out—the course followed by the raiding aircraft.

It was, apparently, at Yarmouth where the first bombs were dropped at 8.15 P. M. on the night of the German raid. After passing Yarmouth the aircraft appeared to visit many coast towns in succession. At Beeston, Sheringham, and Heacham bombs were dropped, as also at Brancaster. At Snettisham a bomb was dropped quite near to the church. The last town on which bombs were dropped was King's Lynn, whence the aircraft proceeded in an easterly direction, passing across Yarmouth once again and making direct for the North Sea and German territory.

steel is very various; nevertheless, this damascene does not alone confer upon steel the title of damask; on ordinary steel, similar figures may be brought out by subjecting it to corrosion, after having designed upon it the figures required; but whatever pains may be taken to make such resemble genuine damask, the eye of a connoisseur easily detects the counterfeit without examining the quality of the metal. Hence has arisen the epithet of "false damask."

A second kind of damask exhibits also an artificial damascene, which, nevertheless, is peculiar to the metal itself, so that, how oftensoever it is repolished, the same figure will reappear whenever it is subjected to corrosion. This damask is known as "artificial damask." It is composed of several sorts of steel interlaid with iron. The beauty of such damask is various, and consists partly in the quality of the several materials, partly in the skill with which they are worked together. These artificial damasks are chiefly wrought in Asia—viz., India, Turkey, Georgia; but the artificial damasks of Europe have attained as yet no great reputation, because the European workmen are more intent upon producing elegant figures on the steel than in improving the metal itself. Thus the artificial damasks, as those of Solinger and Klingenthal, although exhibiting the damascene, have not the figures characteristic of superior metal.

In fine, whatever may be the beauty of artificial damasks, they will not bear comparison with good natural damasks, for, if filed, the damascene does not reappear.

The natural damasks of Asia differ from the artificial in the reappearance of their inimitable and (so to speak) innate damascene, as well as by the faculty of reproducing the same damascene after having been filed, if the constituent particles remain unchanged.

In Asia we observe many kinds of damask. The difference between them depends upon the places in which they have been wrought, the manner of their fabric, and the various qualities of the material. Those most in use are known by the names of Daban, Kara Daban, Khorussaun, Kara Khorussaun, Gundy, Koum Gundy, Neuris, and Schaum (Syria).

The Orientals judge of the goodness of the damask by its figures, by the color of the ground (that is, the intervals between the figured lines), and by the play of colors. They consider the Daban and Khorussaun (to the latter they sometimes add Kara or black) to be the best blades. The Schaum is the least esteemed. The constant experience of many years assures me that the marks upon which the Orientals found their judgment of the goodness of the damask are a more certain criterion of the true quality of the metal than all the tests to which it is subjected in Europe.

As above stated, the first and most essential sign of the damask is its damascene. In proportion as it is thick, defined, fantastic, in the same proportion is the quality of the metal fine. The thickest damascene is about the size of the notes of music, the middling as large as ordinary print, and the finest is that which we can just follow with the naked eye. As to the method of recognising the quality of damask by its figures, and to the reappearance of the damascene, although they depend upon invariable laws, it were easier to give an idea by samples than by simple description. Nevertheless, it may not be useless here to add certain directions upon the subject, which are not founded upon practice alone, but proved by the process I employ in the fabric of damask.

Like written characters, the damascene consists of points, of right lines, and curves, which serve to distinguish the quality of the damask, as follows:

1. The damascene formed principally of right lines, almost parallel, denotes the lowest quality of the damask.

2. When the right lines become shorter, and are partly replaced by curves, they denote a better quality than the first.

3. When the lines are interrupted, show points, and when the dimensions of the curves increase, this is still a better symptom.

4. When the interrupted lines become still shorter, or rather, when they change to points, as they increase in number, so as to form in the breadth of the steel here and there, as it were, nets, interlinked by threads which undulate in diverse directions from one net to the other. In this case the damask approaches perfection.

Finally, when the nets open farther to form figures resembling grapes, or when they occupy the entire breadth of the steel, and partake it in nearly equal articulations, in that case the damask may be recognized as of the highest possible quality.

Another feature by which the quality of damask may be understood is the hue of its ground. The deeper the tint, the more perfect the metal. The ground of the damask may be gray, brown, or black.

A third feature is the play of colors upon the metal, when its surface is subjected to an oblique light. In observing many thus, we perceive that some among them show no variation of tint, while others take a crimson or a golden hue. The more perceptible this play of colors, the finer the quality of the damask. Nevertheless, this test is affected by the degree of corrosion. When the corrosion is very great the play of color is not observed. No art can produce the red hue upon inferior damask. Therefore, the damask may be divided into two distinct classes—viz., that which has the red hue, and that which wants it.

When the three characters above noted are found in union and at their maximum, we may confidently pronounce the damask to be of the most perfect kind, which will in no case fail of the following qualities:

Perfect malleability and ductility. The hardest possible substance after tempering. The keenest and firmest possible edge. And elasticity, when properly tempered.

The other damasks possess various degrees of perfection, according to the three above-named qualities are more or less remarkable.

Among damasks of inferior quality may be found some inferior to cast steel of medium quality; but it is not known that the best cast steel may compare with the finest damask. Comparative proofs have convinced me that the damask offers the highest possible perfection of steel, and the relations we receive from those who have visited Japan, the Indies, Persia, and Turkey are not so exaggerated as many suppose. A well-tempered saber of good damask will easily sever bones, iron nails, and the most flimsy kerchief as it floats in the air. But I must beg leave to doubt the possibility of performing similar feats with similar ease with European blades, such as those of Kligenthal, as we are assured in a late publication; for I am persuaded that the blades of Kligenthal, of Solingen, as well as those of Zlatoouste, of similar temper to good damask, cannot be compared with the latter, whether in edge, in solidity, or in elasticity.

The employment of damask might, I think, be extended with advantage not only to the fabric of arms, but in general to every steel article requiring edge or solidity.

NOTE BY CAPT. ABBOT.

So far Col. Anossoff, a man whose researches in this department of science have enabled him to revive the natural damask in a degree of perfection which I have never observed in the workmanship even of the ancients, and which certainly cannot be approached by fabrics of any Eastern nation at present existing.

This, it will be allowed, is very high authority; the more especially as the Russian collections exhibit probably a greater variety of damasks than those of any other European nation. And to differ in any point with such an authority may not only seem presumptuous, but may absolutely insure the rejection of my opinions as futile. Nevertheless, as I have taken upon me to reprint his valuable remarks in a work of my own, it seems incumbent upon me to add to them some of the results of my own experience.

The blade known in Khorussaun as *the* Khorussaunie blade has a very dark hue, betraying a steel highly carbonized. The figures of its damascene are very curious, and I despair of giving any distinct idea of them without the aid of plates.

1. The kind least esteemed is a light gray, having a granulated surface, the spots of which are rather long in the course of the metal. This kind is also forged at Lahore and Sirore.

2. The second kind has a figuring of coarse dark lines upon a gray ground, these lines exhibiting figures almost precisely similar to the grain of a young oak, when the oblique section has passed near the center of the tree.

3. A third has the same gray ground and dark, irregular lines; but these are more continuous, and not disposed in concentric figures, but have rather the appearance of tissues of wire, running into every serpentine shape.

4. A fourth is a repetition of the last, but the lines are finer, and the figures more uniform in their irregularity, forming homogeneous masses, so to speak. This is the kind most highly esteemed by the people of Khorussaun. It varies greatly in beauty and value, and may be purchased at from £5 to £500.

5. A fifth kind exhibits a series of articulations, of which I have counted thirty-six in a sword-blade. These articulations, or knots, are formed by dense masses of nearly parallel lines, disposed lengthwise in the blade; the masses running into one another. At the junction they are excessively fine. On turning the blade, it will be found that each junction on the one side corresponds with the center of a mass on the other; a proof that the blade had been formed of two distinct laminæ welded together, and a strong presumption that the articulations are artificial, and that the junc-

tions are considered by the workman as the weak points of the steel. This is certainly the most beautiful variety of Khorussaunie blade; but I have not observed that it is so highly esteemed as the finer kinds of the foregoing variety. It varies greatly in quality, the finest lines denoting that which is considered best.

All these blades, when attentively scrutinized, will be found to possess a seam down the back, betraying the welding of the double plate of which they are composed. None of them possess any elasticity. They will either break short, like cast iron, or bend like lead. I have never observed in the finer kinds any superiority in edge over the elastic blade of Germany; but the inferior kind, being often more highly tempered, are keener and very brittle. Their shape is a simple and often abrupt wedge, the very worst shapes for cutting, owing to the great friction which the lips of the wound exert upon the sides. Their figure is too crooked for defense. They are not esteemed unless a cat can walk under the curve when placed edge upwards on the earth; neither is this degree of curve sufficient to confer great value, unless it be elegant in its gradations. The edge is generally obtuse, and seems formed rather to bear the shock with armor and with other blades, than to cut deep. The breadth is seldom great, but they are thick at the back, and always ill-poised. The best are from Isfahaun; but I understand that the art is almost lost, even there. The best I have ever seen I bore as a present from the King of Khaurisn to the Emperor of Russia. Its ground was a grayish azure, in which the lines were most delicately traced in somewhat darker dye. It was not articulated. The back had a coarse seam throughout its extent, which had been so imperfectly welded that the blows of the Kuzzauk clubs opened it. This seam is, I think, invariable in the finer Isfahaunie blades. I believe the object of it is to be twofold. In the first place, to have as large a surface as possible purified by the action of the hammer; and, secondly, by doubling back the plate, to secure an edge free from wiry particles. The blade in question had very little elasticity. I have never seen a Khorussaunie saber pointed with a double edge. It is true that the blade is too crooked to be used in thrusting; yet I have seen Damascus blades equally crooked, that had the double-edged point.

The daggers of Khorussaun are somewhat different in water or damascene from the sabers of that country; greater care seems to have been taken in the process. The lines upon them run into the most delicate and perfect spirals and minute curves. Their appearance, I should say, offers abundant evidence of their being forged of mixed metals; probably they are bundles of wires, of spiral form, welded together in a mass. They are generally of the most elegant figures, seldom double-edged, probably from the superstition against this figure prevalent at Khiva, where the double-edged dagger is religiously disused, because Hosein, the son of Ali, was slain with a double-edged knife. The point is generally triangular and tapering, serving well to force the links of chain armour, which was once commoner than at present. They have, however, a double-edged dagger called Khunja, which is worn in Persia, although the people being Sheeahs, are so much more interested in the fate of Hussun and Hosein.

One of the peculiarities observable in all good Khorussaunie blades is that toward the edge the hue of the steel increases in depth, betraying more strongly the presence of carbon; a fact which proves that a mixture of metals was employed in this species of damask, the harder disposed toward the edge of the blade, the less brittle at the back, with the view to combine the greatest keenness of edge with tenacity to resist concussions.

In Col. Anossoff's Oriental nomenclature occur several names unknown, I think, in Khorussaun and India; for instance, Dabun Gundy and Neuris. Upon these I can, of course, offer no remarks. But with respect to the blade of Schaum, I know not how the Tartars dwelling in Russia may apply the epithet, but its real and original meaning is the blade of Damascus; a city which has given name to all steel fabrics exhibiting upon their surface what is termed water. It is true that the art of damascening seems in the present day to be lost at Damascus, and the blades forged in Syria may, therefore, deserve the contemptuous estimate which the Tartars of Russia seem to entertain for them. But there can be little doubt that of all watered blades the Damascus blade was the most perfect, and the only blade of this description, anciently forged, that had any elasticity. I confess I have never met with an elastic Damascus blade; but there seems to be sufficient evidence that the ancient fabric was elastic. We read an absurd account of a Damascus blade, appertaining to the celebrated Kaliph Haroon ool Rusheed, so elastic, that the monarch usually carried it coiled up like a watchspring in his turban, and travelers give frequent testimony to its elasticity. As few Asiatic swords are flexible, the idea could not have entered the mind of an Asiatic without some foundation in fact. And as European travelers would naturally, after the fashion of their people, test any sword brought for examination by bending it, they could scarcely have fallen into error as to the elasticity of these blades.

A blade that was in my possession, essentially different from those of Khorussaun and India in figure and texture, and wrought in Egypt, probably by Syrian workmen, exhibited the most exquisite water, and an edge that I have never seen equalled; but, although not brittle, it was unelastic. Its structure could scarcely be attributed to the natural arrangement of fiber of the steel in the process of crystallization. I have no doubt that the blade of Damascus was of this character, though probably in the present fabric iron has been substituted for soft steel, and thus the elasticity is lost. It is to be observed that such blades are generally so massive as to render elasticity a matter of little moment, as they will not shiver in any concussion, and scarcely any force to which a saber is liable will materially impair their straightness. Their color is a very pale azure. The streaks are delicate, elegantly waved, and curved, much fainter than in the Khorussaun blades, and appear to be brought out without aid of acids, by the mere action of the atmosphere. Nothing that I have seen approaches in beauty to these blades, or in firmness and keenness of edge. The people of Khorussaun term them Misrie, that is, Egyptian, and believe that they will never steel. The kingdoms of Egypt and Syria having for some time been under one rule, I have little doubt that whatever art of damasceening remains in either land will at present be found at Alexandria and Cairo.

The streaked damask, spoken of in Col. Anossoff's memoir, I have not noticed, because I do not conceive it to deserve the title, being a wretched imitation of the Khorussaun blade.

The Russian damask, on the contrary, discovered by my friend Col. Anossoff, is natural. It is a peculiar modification of cast steel, by which it is impressed with a peculiar character in its crystallization. Which character betrays itself when the corrosion of acids, by acting more violently between the interstices of the structure than elsewhere, traces out the arrangement of the crystals. This property is communicated to the damask of Zlatoost by a process, tending to perfect the quality of the steel, and to impress upon cast steel the elastic properties of a softer material. The general fault of European blades is that being forged of shear steel for the sake of elasticity, they are scarcely susceptible of the keen edge which cast steel will assume. The genius of Anossoff has triumphed over this objection, not in hardening the soft steel, but in giving elasticity to the hard; and it may be doubted whether any fabric in the world can compete with that of Zlatoost in the production of weapons combining in an equal degree edge and elasticity. The water of this variety of damask resembles most that of No. 5 of my list above. It is a succession of small bundles of almost parallel lines, occupying the whole breadth of the blade, the ends of the bundles crossing and mingling at the point of junction. I have called them nearly parallel lines, because such they are to superficial observation. They are, however, a series of minute curves, forming together lines disposed in bundles articulated together, and dividing the length of the weapon into many sections. They have not the regular articulation of the articulated Khorussaunie blade, but their lines are infinitely finer. I have seen several, which were condemned for insufficient temper, submitted to the action of the engine by which they are broken. The blades were bent double and back again several times ere they could be divided. The red hue observed upon damask blades I have seen only on those of Zlatoost.

The Reaction of the Planets Upon the Sun—II*

Influence of the Earth and a Study of Sun Spots

By P. Puiseux, Member of the Institute, Astronomer at the Paris Observatory

Concluded from Scientific American Supplement No. 2046, Page 187, March 20, 1915

CHECK METHODS.

This result is in a way too beautiful. We had hoped to find only a small influence and we find one so decided that there is little room left for the other planets. Accordingly, search has been justly made for other proofs. We may, for instance, compare—

(1) Only the areas, on the east and west halves, of the groups of long life which have been completely followed across the disk. Here, again, without exception, for all symmetrical pairs of zones, the advantage remains with the eastern half of the disk.

(2) We may retain only the groups of long life seen in more than two successive rotations, neglecting the first and last appearances, keeping only the intermediate appearances. It is evident that in this way no appearance can be omitted or fictitious disappearance be registered. Despite these safeguards, the eastern portion still retains its advantage in the proportion of 19 parts in 100.

(3) We may substitute for the spot statistics those obtained from the protuberances observed on the east and west limbs and see if the protuberances show the same inequalities in activity as do the spots at the limb zones.

The protuberances, we have seen, follow more or less closely the solar cycle in their development. But the methods of observation for the protuberances is quite different than for the spots. Mrs. Maunder found no sufficiently complete and homogeneous series of observations of the protuberances for the interval 1880 to 1901, which her spot statistics covered. The studies of Ricco at Catania, however, cover well the interval between the last two spot maxima. Diagrams made from this data show that from 1892 to 1900, during the decrease in spot numbers, the eastern limb had on the average more protuberances than on the western limb. The opposite condition held from 1900 to 1904, but after the spot maximum was reached in 1905 the eastern limb again regained its ascendency. On the average, the eastern limb maintained a superiority of 1 to 20, less constant and less marked than in the case of the spots, but in the same sense.

Deslandres has recently pointed out a circumstance which may render the protuberances more easily visible on the east than on the west border. The sun, which we have reason to believe is electrified at its surface, must by its rotation create a magnetic field. The very mobile protuberances would be disturbed by this field so as to be bent at their upper part in the direction of the rotation. An observer would then not be in an impartial position relative to the two limbs of the sun. He will see better the oncoming protuberances which would be bent toward him than the disappearing ones which would be bent away. This hypothesis seems to be confirmed by the deformations and velocities of the protuberances.

A similar explanation is not so easy in the case of the spots. In order that they may be more easily visible on the eastern than on the western limb, we may suppose that they are followed, but not preceded, in their general rotation by some kind of a cloud. Each spot would then have its cloud, allowing the spot to be seen as it approached but hid more and more as it departed.

This explanation is not very convincing. In order that the cloud have an appreciable effect upon a great spot it would have to be at quite an elevation, and it is difficult to see how it would escape observation at the border of the sun. Its influence would not be felt except toward the ends of the spot's transit, and we have seen that the inequalities are noted in the same sense in all pairs of symmetrical zones.

(4) There remains one more test which we must not neglect. We could not pretend that the earth alone has such an influence upon the sun. If it is effective, then the other planets must be; and there are apparently three, Jupiter, Mercury, and Venus, which should be even more effective. How can we assure ourselves in this matter?

* Lecture delivered at the Conservatoire des Arts et Métiers, February 23rd, 1913. Translated from *Revue Scientifique*, Paris, May 3rd, 1913, in the Annual Report of the Smithsonian Institution.

RESEARCHES OF THE KEW OBSERVERS.

The problem had already been attacked long ago by De la Rue, Balfour Stewart, Benjamin Loewy, astronomers at the Kew Observatory. (*Proc. Roy. Soc.*, p. 210, 1872). As the observations never related to but a half of the sun at a time, it was considered necessary at the start to determine and try to eliminate the influence which the position of the observer on the earth might have. The two following conclusions resulted from the preliminary examination:

(*a*) Upon the hemisphere visible from the earth the mean area occupied by the spots increases as the distance on either side of the central meridian increases.

(*b*) The spotted surface on the average is greater on the western than on the eastern half of the visible disk.

The second conclusion of the Kew observers is at variance with that of the more recent investigators. However, the years examined in the two cases have no part in common. The data used by Mrs. Maunder was so much more homogeneous and abundant that her conclusions should have greater weight.

Having completed their first examination, the Kew observers considered how to correct their data for the position of the observer. They could then, for any planet whatever, P, compare the hemisphere turned toward the planet P with that turned away. Relative to the circle limiting these two hemispheres, any other planet, P', could have any possible position in its orbit. It seemed right to admit that, if the interval considered be long enough, the effect of P' would be eliminated and the effect of P would become evident by comparing the conditions on the two hemispheres.

It was found thus that the spotted areas tend to increase opposite to Mercury and Venus. Jupiter, upon which the greatest hope was placed, gave no definite result.

The work of the Kew observers has been rather severely criticized. The interval used seems too short for assuming the proper compensations, and the gaps in the data are considerable. The choice of the material selected has not always seemed justified.

RESEARCHES OF SCHUSTER.

In a recent memoir (*Proc. Roy. Soc.* 85A, p. 309, 1911) A. Schuster considered it advisable again to take up this problem, using the Greenwich photographs for the years 1874 to 1909. He considered only the births of spots lasting over the interval between the plates of two successive days. He excluded, as more subject to error, those births which, seen from the earth, appeared at less than 30 degrees of longitude from the eastern border. There remained 4,271 spots to consider.

For each planet P, the sun was divided into 12 equivalent vertical zones. The solar meridian passing through the planet P formed the boundary between the zones 6 and 7 on the hemisphere toward the planet and between 12 and 1 on the farther side. The number of spots seen for the first time in each zone was counted and used to form a plot having as abscissæ the zone numbers.

The results are rather irregular especially if—as Schuster did at first—we consider separately the spots counted when the earth is east or west of the central meridian. Of the three planets—Mercury, Jupiter, or Venus—each one seems to produce a minimum of spots where another may produce a maximum. If the above distinction is not made, the results seem more concordant. For all there is a minimum upon zone 3, that is when the planet is just rising, and a maximum on zone 8, which has already passed the meridian. This can be compared with the diurnal march of temperature on the earth due to the influence of the sun's heat. But there are other intermediate maxima and minima for which the three planets are in no ways in accord.

Schuster, however, considers that the similarity of march of the three curves for divisions 3 and 8 is sufficiently characteristic for rendering very probable the reality of a planetary influence.

This march is very different from that which had been found for the earth and much less definite. The effective activity of the earth is therefore apparently of another nature and relatively stronger, or it is only apparent and due to the situation of the observer.

The question was next taken up whether the distribution of spots in longitude did not become more unequal when the three planets considered, or two of them, were in conjunction for the same solar zone. The plots were remade considering only the spots born when that condition was fulfilled. No marked difference was evident. It seems as if the number of spots appearing in a zone is greater only when one of the planets in the conjunction, or slightly past it, is Venus. Schuster thinks that a planet may have merely an exciting action, effective only in putting into play a force already existing in the sun. Accordingly, a second planet on conjunction might not have any additional effect.

RESEARCHES OF F. J. M. STRATTON.

Stratton (*Monthly Notices*, 72, p. 9, 1911) thought that it would be worth while to again take up this research, considering the disappearances as well as the appearances, and retaining only those which occur at less than 50 degrees from the solar meridian passing through the earth. He considers only Jupiter and Venus, which seemed the most probable as having an influence on the spottedness. The period used was the one of 36 years, 1874 to 1909, for which the photographs of the Greenwich Observatory furnished a complete series.

The surface of the sun was divided into 24 equal zones instead of the 12 which Schuster used. The origin was the meridian passing through the planet at the moment of birth or disappearance of a spot. The zones 1 to 6 corresponded to meridians which had already passed over the planet but which are now hid from it. The zones 18 to 24 correspond to meridians which are to transit but which are still out of sight.

He then constructed for each planet plots in which the abscissæ were the zone numbers and the ordinates—

(*a*) The number of spots seen for the first time in each zone.

(*b*) The number of spots seen for the first time in the northern part of each zone.

(*c*) The number of spots seen for the first time in the southern part of each zone.

(*d*) The number of ephemeral (that is, seen for one day only) spots seen in each zone.

(*e*) Total number of spots seen either for the first time or for one day only in each zone.

This gave five curves for each planet. These were remade, using the spots seen for the last time instead of those seen for the first time; that is, disappearances instead of appearances.

The plots were very irregular. Generally there was no similarity in their contour, even for the same planet, between the two hemispheres; neither was there between the same hemispheres for different planets. There is one single coincidence, perhaps, which seems not due to chance. There is a maximum of ephemeral spots noted in the zones the meridians of which either Jupiter or Venus had already passed three hours previously.

It is notable that for this interval of 36 years a terrestrial observer always notes in the central region of the sun more disappearances than appearances. The difference reaches 10 parts per 100. This agrees with what Mrs. Maunder found for the interval 1889 to 1901. For Jupiter and Venus the births seem more frequent when the planet is above than when under the horizon, that is, in the opposite sense from what Mrs. Maunder found for the earth. But the difference is very small and merits no physical explanation.

The relation between the east and west hemispheres of the sun, as seen from a planet, is for Venus in the opposite sense than is the case for the earth. In the case of Jupiter there is scarcely any difference, as the following table shows:

Spots seen on the hemisphere of the sun toward a planet.

	East half	West half.
Jupiter	8,702	8,711
Earth.	8,214	7,508
Venus	7,834	8,368

Another comparison may throw some light on the matter. When a planet is on a given side of the equator is the hemisphere on the same side as the planet especially favored with spots? The reply is contained in the following table:

Planet.	South, number of spots		North, number of spots.	
	South.	North.	South.	North
Jupiter	8,419	5,021	5,785	5,031
Earth	1,512	1,254	1,485	1,329
Venus	6,931	5,750	7,381	6 212

This table seems significant if only the left half is considered. But the preponderance in the southern hemisphere continues whether the planet is to the south or to the north. That is, in the interval considered, the southern hemisphere of the sun had habitually more spots. This may be due to causes within the sun and to no influences from the planets.

This simple comparison leads us to suspect that the concordances noted in the plots for the various planets may be due to causes within the sun. There are two possible reasons for the inequalities in the plots:

(*a*) Any given zone relative to the planet can remain invisible from the earth for months.

(*b*) The epoch when a particular planetary zone may be favorably seen by a terrestrial observer may fall sometimes in the spot maximum phase, sometimes in the minimum phase.

The second perturbing effect is graver than the first. The period of 36 years embraced by the Greenwich data is not sufficiently long to assure us that these two sources of error are eliminated. The method should not be abandoned, but we must get more observations.

CONCLUSIONS.

It would be presumptious to say that we have unveiled the mode in which the planets may react upon the sun, but we feel persuaded that some reaction exists and that it will not always elude us. The sun may have within itself the reason for its period, but it does not keep to itself its rythmic action. It has not sufficient store of energy in the mutual attraction of its parts, in its rotation or in the active force of the planets, there remains a resource in the cosmic dust. Perhaps it is not the matter condensed into the shining stars but that which is scattered in impalpable particles throughout space which contributes more to the stability of the universe.

It seems to me that these views suggested by the study of the heavens help to keep us even in every-day life from discouragement and indifference. The historian, whose attention is focused on salient events, may believe that the human race exists only for a few marked men. The naturalist, accustomed to note the annihilation of the weak, cries willingly with the poet, "Le vent n'écoute pas gémir la feuille morte" (The wind hears not the sigh of the lifeless leaf). But that is only apparently true. The dead leaf, in its manner and measure, reacts on the wind. Already religious moralists warn us that every act, no matter how small and weak, has a sovereign value when it is done in conformity with the eternal order. And this conclusion will not surprise the geometrician, who is constrained to weigh all in an impartial balance and recognizes in the smallest corner of the universe an unlimited influence with regard to space and the future.

Fuel Oil on Railroads*

It has been customary to gage the use of oils for fuel in the United States largely by the consumption by railroads, because the statistics of such consumption may, by careful inquiry, be obtained with approximate accuracy, while consumption in other lines of industry is extremely difficult of determination.

The use of fuel oil by the railroads of Texas was originally due to the sudden flood of cheap oil from the Beaumont region in 1901. The continuance of this trade has lately been aided by imports from Mexico. The ease with which these Texas oils can find other markets than the railroads and the fact that the railroads can return to coal without very serious disadvantage make the future of locomotive consumption of fuel oils in Texas uncertain.

In California the railroads were the first to absorb large quantities of California oils. This legitimate use has become permanent from lack of other fuel, and it has extended to other kinds of generation of power, including marine transportation for shipments coastwise and to foreign countries.

A serious menace to the continued use of oil for fuel in California is the recent change in the character of the crude oils of that State. Many of the new pools yield oils suitable for refining and for the production of large quantities of gasoline and kerosene. Up to the beginning of 1913, about 30 per cent. of the oils of California were refined and the rest was sold for fuel as crude or after very light distillation of the lightest products. This practice changed materially during 1913, so that the proportion of crude oil used direct as fuel became reversed, and, although no accurate figures are available, 70 per cent is about the proportion of crude oil which was refined during that year before the heavier portions were sold for fuel. The result of this, however, will be not to decrease the use of oil for fuel, but to change the method of its application, particularly to the internal combustion engine burning kerosene and heavier distillates.

Although the use of fuel oil extended to a greater number of miles of railroad, the quantity of oil consumed by these railroads decreased slightly and the total mileage made by oil-burning engines decreased in similar proportion, leaving the average number of miles made per barrel of oil consumed the same in 1913 as in 1912.

If it were possible to give a complete statement as to the tonnage moved per barrel, it would undoubtedly show an increase on account of the heavier trains moved, which is offset as to consumption of oil by the increased efficiency of new oil burners, arrangement of oil tanks, and increased skill developed by the firemen.

During 1913 three railroad companies discontinued the use of fuel oil and returned to coal, impelled not only by the advancing tendency of fuel oil prices, but by direct notification from refineries that continuation of contracts would be impracticable. The increase in demand for light products from crude oil has reduced the volume of residuum available for locomotive and other fuel use to a point approximating only 30 per cent of that obtained when gasoline was not in strong demand.

* From the report of the United States Geological Survey on the Production of Petroleum in 1913.

Photographing Projectiles—I*

Securing Records by Means of Illumination from Electric Sparks

The following article is for the purpose of enlarging upon the methods adopted in 1887 by Prof. E. Mach, in collaboration with P. Salcher and L. Mach, for obtaining photographs by means of the electric spark.

Mach's electric spark photography has been so widely quoted in all sorts of technical periodicals, that its fundamental principles may now be considered as generally known. E. Mach himself employed for his photographs a condensing lens, that is to say, a concave mirror in conjunction with a camera. V. Boys at a later date (1890) modified Mach's methods by obtaining, by means of the electric spark, simple shadow pictures (silhouettes) of approximately full size upon sensitized plates, without using concave mirrors or lenses. The methods are similar in that a shadow picture of the object is obtained, that is to say, a silhouette, in which the outline alone of the various objects appears. Examples of such silhouettes are shown in Figs. 1 to 7.

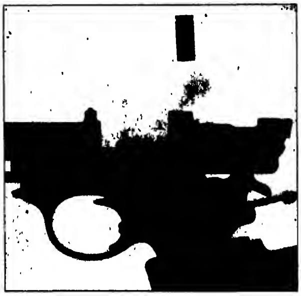


Fig. 1.

Fig. 2.

Fig. 3.

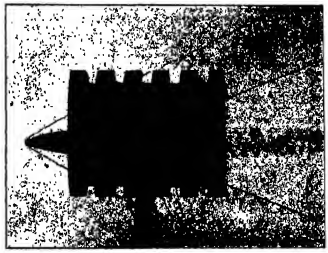


Fig. 7.

Fig. 1, a print made by the simple shadow method of V. Boys, shows an automatic pistol at the moment of discharge.

Figs. 2 to 6 are photographs taken by the Mach process in conjunction with the Töpler obscuration, or light reducing, process.[1]

Fig. 2 shows a small-arms bullet, with head waves, tail waves, and eddies behind the bullet; the photograph was taken with a slight degree of obscuration (*abblendung*). The bullet has just perforated a screen. Fig. 3 represents the same with a stronger obscuration; here the bullet has almost passed beyond the field of view. At the place where a little wooden screen has been perforated by the bullet, an impact wave of air has broadened out to spherical form; and the same thing has occurred at the corner of the table on which the little wooden screen stands; also, the position of discharge of the electric spark is visible at the extreme right edge of the field of view. The headwaves are reflected by the table top according to the law of mirrors. In Fig. 4, the bullet has passed through a metal tube. The waves which originally accompanied the projectile have been cut off by the tube, and appear as sections of circular arcs, which was naturally to be expected. After passage through the tube the waves have formed anew.

Similar photographs were earlier obtained by T. Terada and M. Okôchi in Tokio (see the Japanese periodical *Tokyo Sugaku-Buturigakkwai Kizi*, 2d series, Vol. IV, No. 20, 1908, page 402, and Plate 11, cuts 13 to 15).

Figs. 5, 6 and 7 were obtained in the Laboratory for Ballistic Instruction. It is to be observed that the head and tail waves are to be considered as envelopes of Huyghens' elementary waves. The bullet passes through a metal tube open at the ends and perforated above and below with many holes. We see in Fig. 5 how the elementary waves formed by the holes are enveloped by the head wave. Fig. 6 is the same taken an instant later; here the tail wave forms an envelope for the elementary waves. Fig. 7 is the same as Fig. 5, except that it is taken by the simple shadow method, without mirrors and lenses.

The shadow methods employed by Mach and Boys cannot be dispensed with, when it is a question of obtaining photographic records of air waves and eddies; for then difference in refractive power (*schlieren*) must be dealt with. On the other hand, where difference in refractive power (*gasschlieren*) does not enter, but it is a question merely of the details of an opaque body, from a ballistic point of view photographs made by ordinary methods are quite satisfactory. In such photographs, as is well known, the face of the object which is toward the camera is illuminated by direct or indirect rays of the sun or some other source of continuous light; but if the object to be caught is in very rapid motion, when continuous illumination is employed, sufficiently instantaneous closing of the shutter must be assured; and while it is possible to obtain in ordinary instantaneous photography an exposure of 1/20,000 of a second, yet even that brief interval is far too great for obtaining sharp definition in the case of many mechanical movements, and especially in the case of those with which we are concerned in ballistics. When, for instance, a wheel of 500 millimeter circumference revolves at a rate of 12,000 revolutions per minute, a point on the circumference has passed over a distance of 5 millimeters in 1/20,000 of a second; so, if the wheel is photographed

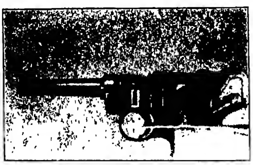


Fig. 9.

Fig. 4.

Fig. 5.

Fig. 6.

*By C. Cranz, P. A. Gluther, Captain, 49th Regiment, Field Artillery, and F. Kilip, Captain, 118th Regiment Infantry. Translated from the *Zeitschrift für das Gesamte Schiess- und Sprengstoffwesen* for the *Journal of the United States Artillery* by Charles A. Junken.

[1]The editor of the *Zeitschrift für das Gesamte Schiess- und Sprengstoffwesen* has kindly explained that this process (*Töpler Schlierenabblendung*) consists in darkening the field of view by means of a blackened metal block advanced so far toward the axial line of the camera lens as to cause the field of view just to begin to show dark. (*Schliere*, a space in which the refractive power differs from that of the surrounding medium. *Abblendung*, obscuration.) —Tr.

Fig. 10.

Fig. 8.

Fig. 11.

Fig. 12.

Fig. 13.

to half size, the definition of a point on the circumference is reduced by its extension through 2.5 millimeters. If a projectile is travelling at the rate of 900 meter-seconds and is photographed to 1/10 its natural size, the definition of a point is reduced by its extension through 4.5 millimeters, since the projectile moves during the exposure 45 millimeters. On the other hand, sufficiently instantaneous exposure is attainable in illumination by means of an electric spark, the duration of the spark light, determined by various methods, being from 1/3 to 1/10 of a millionth of a second.

The method for obtaining a photograph by the light of an electric spark is naturally similar to that employed for securing a photograph of a stroke of lightning on a dark night: the camera is opened till the light shines, and is then closed. C. Cranz in 1909 obtained some

Fig. 14.

negatives by illuminating the face of the object with the electric spark (see *Zeitschrift*, etc., Vol. 4, of 1909, page 323), the spark being discharged through a mercury arc-lamp. Very clear pictures were subsequently published by Herr H. Boas in Berlin, in a privately printed pamphlet, in which the face of the object was illuminated by spark light, a reflector being employed. Among other things, he photographed a revolving wheel (Fig. 8).

By employing a great number of condensers we have lately resumed experiments with face illumination; and in Fig. 9 and those following, we shall, by means of many examples, show that, in face illumination with spark light, details within the contour of rapidly moving objects appear with thoroughly satisfactory definition. Some of those photographs we published in July of last year in *Schuss und Waffe*, Vol. 6, No. 20, page 397; and by arrangements with the editors of both periodicals concerned we republish in the present article, the earlier photographs with slight changes in the accompanying text, and give, in addition, a new series of photographs of ballistic, scientific, or physical interest, as well as some stereoscopic photographs and moving picture films.

The condensers were thoroughly charged by means of a static machine, the available capacity being 45,000. For making Fig. 17, a capacity of about 3,500 was employed. In order to eliminate solitary shadow effects, at least two to four illumination sparks were discharged in series to the right and left of the object to be photographed, and in front of the camera.

The illumination from that spark which corresponds to the final stroke of the battery, due to self-induction, is the shortest and weakest flash.

In addition, small concave mirrors were placed behind the lighting area; moreover, several successful photographs were obtained by means of light projectors placed at greater distances from the object

One or the other position of the sparking areas should be adapted according to the requirements; they will naturally vary with the methods adopted for discharging the illuminating sparks.

Fig. 9 represents the army pistol in a state of rest before firing. On the pistol housing in front of the rear end of the barrel and in rear of the breechblock may

Fig. 14 I.

be seen vertical marks drawn with a white pencil. From the shifting of these vertical marks we may readily determine, at any instant, whether the piece has been fired, how far the breech mechanism has recoiled, etc.

Fig. 10 represents the same pistol during discharge, that is, at the moment when the bullet is 8 centimeters from the muzzle. Powder gases are streaming from the muzzle, and within the powder gas may be seen the position of discharge of the electric spark.

Fig. 11 represents the same pistol at the instant when the bullet is 200 centimeters from the muzzle. The extractor is partially open.

Fig. 12 shows the same pistol when the bullet is 350 centimeters from the muzzle. The empty cartridge case has been extracted and thrown into the air.

Fig. 13 is a double, or stereoscopic, photograph of the same pistol in firing; the powder gases are streaming from the muzzle.

Fig. 14 is a double, or stereoscopic, photograph of the same pistol in firing and its reflected image. In this, not only the pistol itself, but its reverse reflection in the mirror is visible, so that we may observe at the same instant both sides of the weapon. Such photographs have a peculiar value when we are dealing with an automatic arm, because from the front side the action of the extractor is followed with great difficulty. They are also of value in the case of small projectiles, when measuring rotation of the projectile, its oscillations, etc.

Fig. 14 I shows the blast of the black powder gas at the muzzle of the small arm, Model 71, seen from the front. The larger volume of the powder gas is expanding in the form of a mushroom, while in front of this mushroom may be seen that portion of the gas which has been drawn forward by the bullet. By its form the mushroom clearly shows how the rifling has affected it. The several bright lines are the trajectories of the burning powder grains.

Fig. 14 II shows the same taken from the rear, and to one side.

Fig. 14 III is a stereoscopic, or double, photograph of the same phenomena. Examination with the stereoscope affords an exceedingly realistic view of the form of the mushroom and the trajectories of the burning powder grains. For this reason, it may be remarked, many photographs of small shot (not reproduced here) were obtained by stereoscopic methods. Stereoscopic examinations of the shot sheaf permitted such an accurate separation of the individual shot in the direction of the three dimensions, that it was found possible, by means of the stereoscopic scale, to determine not only the extent of separation of the flying shot, but also, from many successive photographs, the reduction in velocity and the rotation of the individual shot. It is probably feasible by such methods to solve many problems which are at present shrouded in mystery. We hope to recur to these matters.

(To be continued.)

A Quality of Electrolytic Iron

If a sheet of electrolytic iron and one of ordinary rolled iron are cleaned of scale and oxide and set up as a battery with dilute sulphuric acid, a millivoltmeter will show that the electrolytic iron is electro-positive to the common iron. It will be appreciated from this that a coating of electrolytic iron is under many circumstances a desirable protective coating

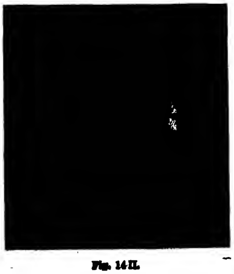


Fig. 14 II.

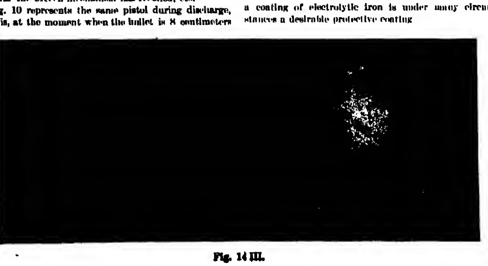


Fig. 14 III.

Making Steel by Electricity*

Various Systems; Their Merits and Defects

The idea of producing steel by electrical methods is more than 60 years old, but no practical solution of the problem was achieved until the close of the last century, when electric furnaces of several distinct types were put into operation.

The oldest of these furnaces, the Stassano furnace (1898), in which the metal is heated entirely by radiation from an electric arc, is now used chiefly for the production of small steel castings, weighing less than 2 tons. It is well adapted for small machine works which make their own castings, and for all cases in which it is undesirable, for any reason, to intrust the work to an outside foundry.

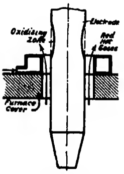


Fig. 2.—Oxidized electrode.

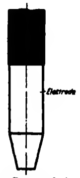


Fig. 3.—Protected electrode.

At nearly the same time appeared the Héroult furnace with two or three vertical electrodes placed immediately over the metal. This is the most widely used of all electric furnaces. It is suitable both for fusing cold scrap and for refining molten metal, and it is employed in many steel works in capacities up to 25 tons.

The Girod furnace, with one electrode above the metal and one or more in the bottom of the furnace, was first designed (1906) to use monophase alternating current, but it was subsequently adapted to the employment of triphase current also. Its field of usefulness is the same as that of the Héroult furnace, but no Girod furnace of greater capacity than 15 tons has yet been constructed.

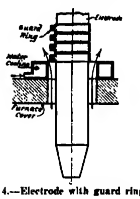


Fig. 4.—Electrode with guard rings.

The Keller furnace, based on a similar principle, is used chiefly in France, and far less extensively than the Girod furnace.

The Nathusius furnace, which appeared in 1908, differs from all other furnaces with bottom electrodes in allowing a current to be established between the bottom electrodes, as well as between them collectively and the upper electrodes. In this way the distribution of heat through the charge can be varied at will. The largest Nathusius furnaces yet constructed have a capacity of 10 to 12 tons. The field of utility is similar to that of the Girod furnace, but the Nathusius furnace is said to be peculiarly well adapted to the smelting of ferromanganese.

Many other electric arc furnaces have been patented, but they differ little from those mentioned above, or from each other.

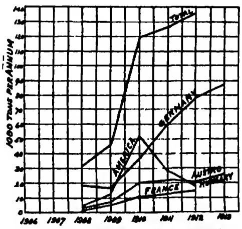


Fig. 1.—Annual production of electro-steel.

Toward the close of the last century, almost simultaneously with the arc furnaces, appeared the first induction furnaces, the Kjellin and the Frick, which differ only in the form and arrangement of the primary coils. The Kjellin furnace may be used in place of the crucible furnace, but it is not very well adapted for refining and it has serious defects which have greatly limited its field of application. Until recently this was equally true of the Frick furnace but the latest form of the latter is said to be very well adapted for refining, and several large Frick furnaces, including two of 20 tons capacity in America, are being constructed for the production of fine steel from molten metal.

The Roechling-Rodenhauser furnace was created in 1906 by combining a number of Kjellin furnaces. (The new Frick furnaces are also of the combined type). The Roechling-Rodenhauser furnace was the first induction furnace employed at all extensively. It is now used chiefly for refining molten metal and for smelting ferromanganese. The largest of these furnaces yet constructed have a capacity of about 12 tons.

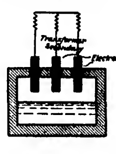


Fig. 6.—Héroult furnace.

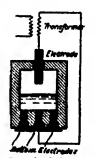


Fig. 7.—Girod furnace monophase current (1906).

Many other induction furnaces have been patented and attempts have been made to combine induction heating with arc heating or with resistance heating.

As nearly as can be ascertained the total number of electric steel furnaces in existence, and in process of construction, in 1913-14 was 173, of which 138 were arc furnaces and 35 were induction furnaces. The arc furnaces included 67 Héroult, 27 Girod, 9 Nathusius, 10 Stassano, 6 Keller, 8 Chaplet, and 11 others. The induction furnaces included 10 Kjellin, 17 Roechling-Rodenhauser, 6 Frick and 2 others.

The following table shows the number of tons of electro-steel produced in various countries in the years from 1908 to 1913, inclusive:

	1908	1909	1910	1911	1912	1913
Germany and Luxemburg......	19,536	17,773	36,188	60,654	79,190	88,981
France.....	2,289	6,456	11,759	13,850	15,922	?
Austria-Hungary..	4,533	9,048	20,028	22,867	21,556	26,837
America...	6,112	13,762	52,141	29,105	18,602	?
Total	32,590	47,039	120,116	126,476	135,270	?

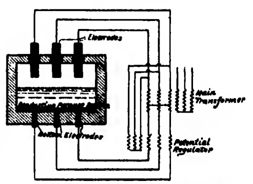


Fig. 9.—Nathusius furnace with patent regulator.

From this table and the corresponding graphical record (Fig. 1), it appears that the annual production, though increasing in Europe, has steadily declined in America since 1910. In general, it is evident that the electric furnace is far less extensively employed than would be expected of a new device of demonstrated practical utility. This slowness of development is due chiefly to the two following causes:

In the first place, at the prevailing prices for electric current the electric furnace can compete successfully with other furnaces only in the production of high grade steel, and even here only when electric energy is comparatively cheap and other conditions are favorable. It is the superior quality of electro-steel that makes successful competition possible. Steel of lower grade can be produced more easily and cheaply by other methods.

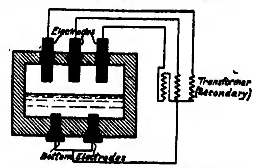


Fig. 10.—Girod furnace for three-phase current (1911).

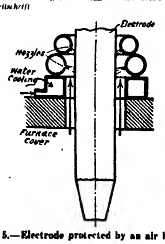


Fig. 5.—Electrode protected by an air blast.

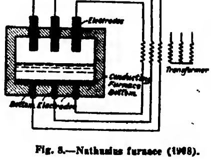


Fig. 8.—Nathusius furnace (1908).

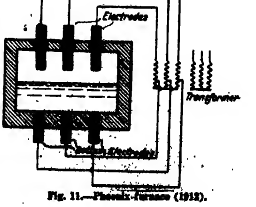


Fig. 11.—Phoenix furnace (1912).

* Abstract of Dr. Sigmund Guggenheim's article in *Elektrotechnische Zeitschrift*

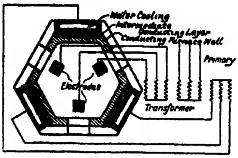


Fig. 12.—Hardén furnace (1914).

In the second place it is very difficult to construct an electric furnace of a capacity exceeding 15 tons. The largest charge now worked is 25 tons and the practical utility of the largest electric furnaces has not been conclusively demonstrated.

An electric furnace can find extensive employment only on condition that it can be connected to a normal triphase circuit of several thousand volts and 50 periods without the interposition of rotary converters, and even static transformers should be eliminated, if possible. At present this condition is satisfied only by Roechling-Rodenhauser furnaces of less than 4 tons capacity. Larger furnaces of this type and all other induction furnaces require for economical operation currents of low frequency (5 to 25 periods). Induction furnaces in general require special generators or rotary converters which greatly increase the cost of installation.

Arc furnaces usually dispense with rotary converters as they can use a current of 50 periods if the conductors are properly arranged, but they generally require trans-

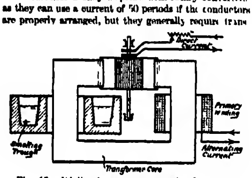


Fig. 13.—Kjellin furnace with device for regulating factor of efficiency.

formers as they are constructed for low voltages. All arc furnaces have the defect that the heating current of thousands of amperes, which in induction furnaces is generated in the charge itself, must be brought in from an external source. A charge of 15 tons requires a current of about 15,000 amperes and the conduction of the still stronger currents required for charges exceeding 30 tons presents difficulties that have not yet been overcome.

One of the greatest difficulties is met in the construction of the electrodes. Large electrodes usually carry 6 or 7 amperes per square centimeter so that a circular electrode carrying 20,000 amperes would have a diameter of 63 centimeters (about 25 inches). Homogeneous electrodes of these dimensions are very difficult to produce and rapidly disintegrate.

The life of the electrode is shortened by oxidation. In order to allow the electrodes to be pushed down as they are consumed at the lower end they must pass through the furnace cover with some clearance through which burning gases escape and oxidize the upper parts of the electrodes (Fig. 2). When the gradual lowering of the electrode brings this partly consumed portion to the furnace cover the clearance and the evil are increased. For this reason it is customary to protect the upper portion of the electrode by a water-cooling device (Fig. 2), or a collar of wire netting coated with cement (Fig. 3), or both.

The insufficiency of these precautions is proved by the number of recent patents for improved methods of protection. The preparation of the electrodes is very laborious as the cement-coated netting must be applied in the moist state and allowed to dry on the electrode. For this reason one firm proposes to substitute for the netting a number of separate and easily removable guard rings of refractory material (Fig. 1). Another patent covers the suppression of the outflow of furnace gas by a counterblast of air or steam from nozzles surrounding the electrode (Fig. 5).

The arrangement of the electrodes in various arc furnaces is illustrated in Figs. 6 to 12. All except the Héroult and Stassano furnaces employ bottom electrodes. The bottom electrodes of the Girod furnace have the same potential so that no current flows between them, but those of the other furnaces have different potentials and produce currents in a conducting layer of the furnace bottom or wall.

In the Héroult furnace the heating effect is produced entirely by the arc above the charge. To this the Girod furnace adds the heating effect of the current through the charge and the Nathusius adds also the heat produced by the current in the furnace bottom. This bottom heating can be varied within wide limits by means of a potential regulator and in this way the load on the upper electrodes can be diminished.

The defects of the induction furnace are even greater than those of the arc furnace. The electrical defects of the former have already been mentioned. Its most serious metallurgical defect is the absence of a simple closed hearth. The melting troughs of the Kjellin and Frick furnaces are not very well adapted for refining and even the combination of several such troughs in the Roechling-Rodenhauser furnace is not entirely satisfactory for this purpose. Another defect of the induction furnace is the impossibility of melting cold charges without the aid of special auxiliary devices.

Attempts to increase the efficiency of the induction furnace have been made by increasing the resistance of the melting troughs, by adding other resistance heating to the induction action and by modifying the arrangement of the primary coils. A Baden firm has tried to improve the efficiency of the Kjellin furnace by a radically different method (Fig. 13). The transformer core includes a disconnected segment which is capable of rotation and is energized by a direct current flowing through an enveloping coil. The primary coil of the furnace is connected as usual with an alternating circuit. This arrangement constitutes a synchronous motor so that the magnetized segment if it is rotated in synchrony with the alternating current will continue to rotate at the same speed. The primary difference of phase can then be regulated at will by modifying the exciting direct current.

Attempts to melt cold charges in induction furnaces have proved equally futile. The introduction into the melting troughs of iron rings to serve temporarily as closed secondary circuits is troublesome and it is usually inadmissible for chemical reasons in the production of high grade steel.

Special attention has been given by inventors to the construction of a hearth suitable for metallurgical purposes and many patents have been issued in this field. The Roechling steel company has patented two furnaces with simple closed hearths (Figs. 14 and 15). In the standard Roechling-Rodenhauser furnace only a small portion of the secondary current is produced in a secondary wire coil and communicated to the charge through electrodes, but in the new Roechling furnaces the whole of the heating current is so produced and communicated. Hence these furnaces are not induction furnaces but resistance furnaces operated by transformers. The peculiar advantage of the induction furnace, the generation of the strong heating current entirely in the charge itself, is forfeited, and the advantage of the simple hearth without troughs is offset by the necessity of constructing external conductors and electrodes capable of carrying the strong current safely and efficiently.

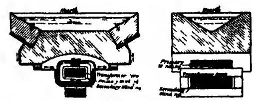


Fig. 15.—Longitudinal and transverse vertical sections of second improved Roechling furnace (1912).

On the whole it appears that the induction furnace at present is even more deficient than the arc furnace in the qualities requisite for extensive employment. This is probably the reason why the number of induction furnaces increased only from 30 to 15 between 1908 and 1913, in which period the number of arc furnaces increased from 13 to 138.

The advocates of the arc furnace assert that a thin-flowing slag of higher temperature than the metal beneath it is absolutely necessary for good metallurgical work, and that this condition is satisfied only in the arc furnace where the heat is produced at the surface. In the induction furnace the heat is generated in the metal which consequently must be hotter than the slag. It is possible, however, to raise the temperature of the charge in the induction furnace far enough above the fusing point to produce a thinly flowing slag.

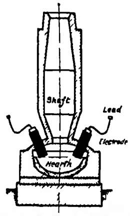


Fig. 16.—Swedish electric ore reducing furnace.

The electrical reduction of iron ore has recently been attempted, and with some success. In Scandinavia and California, where water power is cheap, this method has been profitably employed for several years.

Most of the experiments in the electric production of pig iron have been made with arc furnaces. Stassano's first furnace was designed for the reduction of iron ore. Subsequently Keller and Héroult experimented with arc furnaces but the first practical success was obtained in Sweden by Gronwall, Lindblad and Stalhane, whose experiments began in 1907.

The ore reducing furnace of Gronwall, Lindblad and Stalhane (Fig. 16) is very similar in form to the ordinary blast furnace. Experiments with these furnaces are now being conducted on a large scale, but the results yet obtained do not absolutely assure commercial success.

In Germany Helfenstein has obtained good results with both arc furnaces and induction furnaces. His induction furnace, like the new Roechling furnace, is essentially a resistance furnace in which the charge forms part of the secondary circuit of a transformer.

Among the many patented systems of electric ore-reduction one of the most interesting is that of Hering, who employs the resistance furnace shown in Fig. 17. Fusion takes place in the two lower shafts from which the molten metal is continuously expelled by the so-called Pinch effect, first made known by Hering, and is replaced by fresh material entering through lateral channels. Fig. 18 shows this furnace combined with a steel furnace into which the molten iron is discharged.

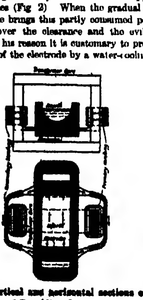


Fig. 14.—Vertical and horizontal sections of first improved Roechling furnace (1912).

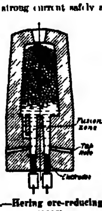


Fig. 17.—Hering ore-reducing furnace (1913).

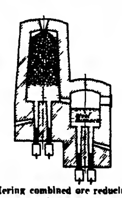


Fig. 18.—Hering combined ore reducing and steel furnace.

NEW BOOKS, ETC.

SCIENCE AND METHOD. By Henri Poincaré. Translated by Francis Maitland. With a preface by the Hon. Bertrand Russell, F.R.S. London and New York: Thomas Nelson & Sons.

While there is much in this book of the wonderful Poincaré which will be understood and appreciated at its true worth only by the mathematician, there is also a wealth of material which must make its appeal to the general reader. There are general papers on science, on astronomy, and on radium which will awaken the interest of every thinking man. The essays on mathematical reasoning, by far the finest in their way which have come to our notice in many a year, make a special appeal which cannot be ignored. The whole book is a collection of various studies which the late Prof. Poincaré made in scientific methodology. The Hon. Bertrand Russell has written a Preface in which he sympathetically sets forth the significance of Poincaré's work in this age. One must endorse his estimate of Poincaré's writings. "It has the freshness of actual experience," Mr. Russell asserts with justice, "of vivid intimate contact with what he is describing. . . . His wit, his easy mastery, and his artistic love of concealing the labor of thought, may hide from the non-mathematical reader the background of solid knowledge from which his apparent paradoxes emerge. Often, behind what may seem a light remark, there lies a whole region of mathematics which he himself has helped to explore."

AIR CRAFT IN WAR. By J. Spaight. London and New York: Macmillan & Co., 1914. Price, $2.

Dr. Spaight's book considers the military uses of flying machines and airships from the standpoint of international law. His book appears most opportunely, although unintentionally so, in view of the fact that since it was written Zeppelins have dropped bombs on Antwerp and aeronautical machinery has at last been tested. The situations which Dr. Spaight discusses have already arisen in the present conflict. Thus, for example, he considers the right of an airship to drop bombs upon an undefended city, containing barracks, military stores and railway stations—in other words, the Antwerp situation. He finds nothing in international law which could prevent an airship from attacking a town in this fashion. He discusses also the rights of neutral airmen in war zones and finds that they venture within the danger line at their peril. His analysis of the Hague Convention and its influence upon aerial bomb-dropping is illuminating. He considers the provisions against bomb-dropping in the convention moribund, and prophesies that they will be dropped altogether when the next Hague Convention is called. His analysis was written before the war. Recent events lead us to suppose that the opposite effect will result. In some interesting appendices Dr. Spaight discusses various codes which have been proposed from time to time to govern the movements of aircraft in time of war and peace. The well-known code of Fauchille, which was drafted before the aeroplane and airship became such military necessities, comes in for much criticism. Dr. Spaight offers a code of his own which it must be confessed has distinct advantages over that of Fauchille.

ANLAGE UND BETRIEB VON LUFTSCHIFFHÄFEN. Von Dipl. Ing. Christians. München und Berlin: Verlag Oldenbourg. 1914.

It was the Germans who first gave the subject of airship sheds anything like systematic engineering attention. The reason is not far to seek. It was really not until the giant Zeppelins made their appearance that the housing of airships presented any great difficulties. It was no difficult matter to store Parsevals and similar collapsible balloons. The importance of the airship shed has been driven home primarily by the numerous accidents which have been sustained by Zeppelins—accidents nearly all of which have been caused by trying to run a rigid airship into a shed during a gale. In this admirable book of Engineer Christians, all the experience gained by German airship builders and navigators in housing airships is concentrated. So far as we are aware, it is the first trustworthy setting in print of a problem which demands serious attention, now that the Zeppelin airship has come to stay. The United States is still so backward in aeronautics, particularly in the development of the dirigible, that Engineer Christian's book will have more of an academic than a practical interest for our aeronautic engineers, but the time is not far distant, we venture to prophesy, when its pages will be eagerly scanned in this country in order to reap the fruit of German experience.

EVERY MAN HIS OWN MECHANIC. A complete Guide for the Amateur to All Constructive and Decorative Work. By John Barnard. New York: Frederick A. Stokes Company. 8vo.; 504 pp.; fully illustrated. Price, $1.50 net.

Of British authorship, this work differs slightly in both nomenclature and method from American usage. In all other respects it will be recognized as a reliable guide to the amateur carpenter, metal worker, plumber, paperhanger and painterer. The use of tools is naturally given extended consideration, and all kinds of work in wood are given adequate space. Such subjects as inlaying, marquetry and the more advanced handicrafts are simply outlined in suggestive paragraphs. Its appeal is avowedly to the man who takes up some constructive work as a hobby, and to judge it according to the standard demanded by a professional handbook would be an injustice. In its own field it will prove of material aid to the tyro, furnishing hints for household repairs and furnishings that will delight his heart.

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Founded 1876

NEW YORK, SATURDAY, MARCH 27, 1915

Charles Allen Munn, President
Frederick Converse Beach, Secretary
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All at 361 Broadway, New York

Entered at the Post Office of New York, N. Y.
As Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year	. . .	$5.00
Scientific American (est. 1845)	"	4.00
American Homes and Gardens	"	3.00

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SCIENTIFIC AMERICAN SUPPLEMENT

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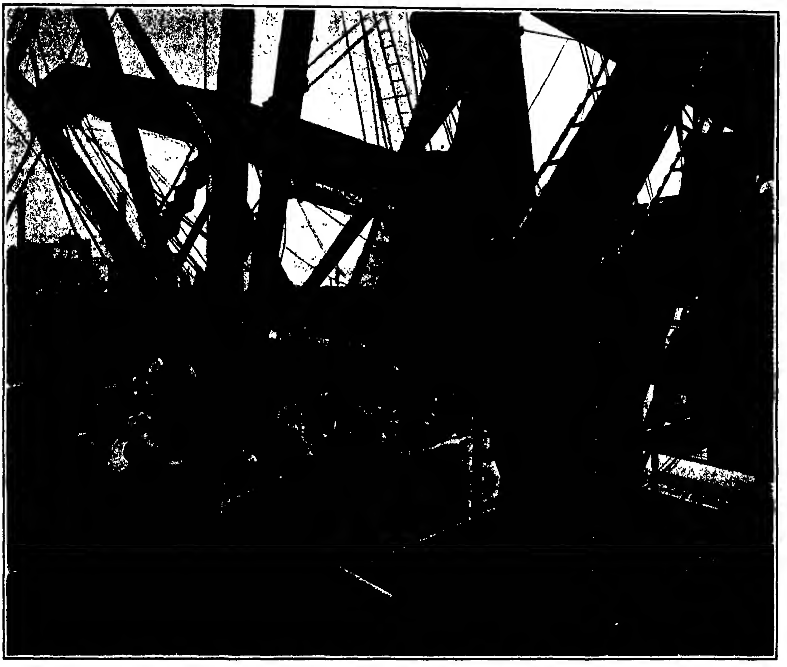
VOLUME LXXIX NUMBER 2048

NEW YORK, APRIL 3, 1915

10 CENTS A COPY $5.00 A YEAR



Scene on a banana laden steamer at the Galveston docks.

Unloading Bananas by Machinery

New Methods of Handling Delicate Fruit Rapidly and Without Injury

The city of Galveston is a port where many shiploads of bananas are received to be unloaded and sent by trainloads to western and southwestern cities, as the banana is eaten as generally as the apple or peach.

Fruits are generally delicate merchandise that require careful handling, and this is particularly the case with bananas, which cannot be conveniently packed, and which, in this country, have such a long journey, with many transfers, before reaching their market.

The unloading of this fruit at Galveston is performed by an ingenious mechanism operated by electricity. Ranged along the fruit wharf are a number of odd looking, pyramidal houses, each with a sort of an elephant trunk protruding from their sides. These are the electrically operated fruit conveyors. As soon as the ship is laid alongside, the trunk swings out and drops a long conveyor belt down through the hatches into the hold. Then the wheels begin to turn and the canvas pockets travel in an endless succession from the hold to the wharf.

Down in the hold the men lay the bunches of bananas onto the conveyor, placing a single bunch in each pocket as it presents itself. As the bunches reach the wharf end they are taken by men who hurry them off to the various railroad cars on nearby tracks. The wharf appears then to be swarming with moving bunches of bananas set on two legs.

An expert freight classifier inspects each bunch as it is carried away. "Number nine!" calls the expert, and the man under the bunch moves to the open door of a car from which a flag displaying the figure "9" is hung. This grade is the highest in bananas, and only the best bunches of the firmest, most mature fruit are so classified; yet most of the bunches brought into this port are of that quality. There are also "eights" and "sevens," these being smaller and riper fruit. As the classifier calls "yellow flag," the toter carries the bunch to a car where riper bananas are loaded, mounting improvised steps and passing his bunch up to the men inside, where it is neatly stacked on the bottom of the car to be shipped to some nearby market where the fruit can be disposed of quickly.

Before this mechanical carrier was put to work it was customary to have a long line of men stationed at arm's length apart, extending from the depths of the hold of the vessel to the freight cars on the dock, who carefully passed the bunches of fruit from hand to hand in endless succession, thus necessitating a large number of men and resulting in many handlings.

There are as many varieties of bananas as there are of apples, and they are both red and yellow in color. At one time it was customary to call the yellow variety plantains, and the red fruit bananas, but authorities agree that there is no specific difference between plantains and bananas. The yellow variety is the kind imported into the United States most frequently, and in the greatest quantities, although in some localities the red fruit is preferred. Most of the latter are the baracoa, or Red Jamaica, while one of the best of the large yellow variety is the Martinique.

A Record of Achievement—I*

The Contribution of the Chemist to the Industrial Development of the United States

By Bernhard C. Hesse

THE CHEMIST AND HIS WORK.

THE American public has seemingly given too little consideration to those industries of this country that make use of chemical knowledge and experience in the manufacture or utilization of products and yet these are the ones that compose chemical industry or industrial chemistry.

The substitution of accurate, dependable, and unfailing methods of operation for "rule of thumb" and "helter skelter" methods must appeal to every manufacturer as a decided advancement and a valuable contribution.

The chemist has made the wine industry reasonably independent of climatic conditions; he has enabled it to produce substantially the same wine, year in and year out, no matter what the weather; he has reduced the spoilage from 25 per cent to 0.01 per cent of the total; he has increased the shipping radius of the goods and has made preservatives unnecessary.

In the copper industry he has learned and taught how to make operations so constant and so continuous that in the manufacture of blister copper valuations are less than $1 apart on every $10,000 worth of product, and in refined copper the valuations of the product do not differ by more than $1 in every $50,000 worth of product. The quality of output is maintained constant within microscopic differences.

Without the chemist the corn products industry would never have arisen, and in 1914 this industry consumed as much corn as was grown in that year by the nine States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Delaware combined; this amount is equal to the entire production of the State of North Carolina and about 80 per cent of the production of each of the States of Georgia, Michigan, and Wisconsin; the chemist has produced over one hundred useful commercial products from corn, which, without him, would never have been produced.

In the asphalt industry the chemist has taught how to lay a road surface that will always be good, and he has learned and taught how to construct a suitable road surface for different conditions of service.

In the cottonseed oil industry, the chemist standardized methods of production, reduced losses, increased yields, made new use of wastes and by-products, and has added somewhere between $10 and $12 to the value of each bale of cotton grown.

In the cement industry, the chemist has ascertained new ingredients, has utilized theretofore waste products for this purpose, has reduced the waste heaps of many industries and made them his starting material; he has standardized methods of manufacture, introduced methods of chemical control, and has insured constancy and permanency of quality and quantity of output.

In the sugar industry, the chemist has been active for so long a time that "the memory of man runneth not to the contrary." The sugar industry without the chemist is unthinkable.

The Welsbach mantle is distinctly a chemist's invention, and its successful and economical manufacture depends largely upon chemical methods. It would be difficult to give a just estimate of the economic effect of this device upon illumination, so great and valuable is it.

In the textile industry, he has substituted uniform, rational, well thought-out and simple methods of treatment of all the various textile fabrics and fibers where mystery, empiricism, "rule of thumb" and their accompanying uncertainties reigned.

In the fertilizer industry, it was the chemist who learned and who taught how to make our immense beds of phosphate rock useful and serviceable to man in the enrichment of the soil; he has taught how to make waste products of other industries useful and available for fertilization, and he has taught how to make the gas works contribute to the fertility of the soil.

In the soda industry, the chemist can successfully claim that he founded it, developed it, and brought it to its present state of perfection and utility, but not without the help of other technical men; the fundamental ideas were and are chemical.

In the leather industry, the chemist has given us all of the modern methods of mineral tanning, and without them the modern leather industry is unthinkable. In the case of vegetable-tanned leather he has also stepped in, standardized the quality of incoming material and of outgoing product.

In the flour industry, the chemist has learned and taught how to select the proper grain for specific purposes, to standardize the product, and how to make flour available for certain specific culinary and food purposes.

In the brewing industry, the chemist has standardized the methods of determining the quality of incoming material and of outgoing products, and has assisted in the development of a product of a quality far beyond that obtaining prior to his entry into that industry.

In the preservation of foods, the chemist made the fundamental discoveries; up to twenty years ago, however, he took little or no part in the commercial operations, but now is almost indispensable to commercial success.

In the water supply of cities, the chemist has put certainty in the place of uncertainty; he has learned and has shown how, by chemical methods of treatment and control, raw water of varying quality can be made to yield potable water of substantially uniform composition and quality.

The celluloid industry and the nitro-cellulose industry owe their very existence and much of their development to the chemist.

In the glass industry, the chemist has learned and taught how to prepare glasses suitable for the widest range of uses and to control the quality and the quantity of the output.

In the pulp and paper industry, the chemist made the fundamental observations, inventions and operations, and to-day he is in control of all the operations of the plant itself; to the chemist also is due the cheap production of many of the materials entering into this industry as well as the increased and expanding market for the product itself.

THE STATISTICAL POSITION.

For the census year of 1909 the wage-earners and the value of manufactured products and the value added by manufacture in twelve of these industries and in the manufacture of chemicals is given in Table Ia.

TABLE Ia	Wage-earners	Product value	Value added by manufacture
Wine	1,911	$11,120,846	$6,493,313
Copper	15,628	378,805,974	45,274,336
Fertilizer	18,310	103,960,213	34,438,293
Textiles	44,046	83,336,632	48,295,131
Canned and preserved foods	59,968	157,101,201	53,278,142
Cotton-seed oil	17,071	147,867,894	28,036,419
Cement	26,775	63,205,455	35,961,664
Sugar	20,730	327,371,780	52,523,806
Brewing	54,579	374,730,096	278,134,660
Leather	62,202	327,874,187	79,595,254
Glass	68,911	92,095,203	59,975,704
Paper and wood pulp	75,978	267,656,964	107,214,625
Chemicals (strictly)	23,714	117,688,887	57,367,351
TOTALS	529,835	$2,455,035,132	$897,688,496

TABLE Ib	Wage-earners	Product value	Value added by manufacture
Iron and steel	278,505	$1,377,151,817	$399,013,072
Petroleum refining	13,929	236,997,659	37,724,237
Lead smelting and refining	7,424	187,409,650	15,442,628
Illuminating and heating gas	37,215	166,814,371	114,386,257
Confectionery	44,638	134,795,913	55,643,140
Paint and varnish	14,240	124,889,422	45,873,867
Soap	12,999	111,357,777	39,178,359
Carpets and rugs	33,307	71,188,152	31,625,148
Explosives	6,274	40,139,061	17,328,113
Zinc smelting and refining	6,655	34,205,894	8,975,893
Turpentine and resin	39,311	25,295,017	20,384,174
Oil cloth and linoleum	5,201	23,339,022	7,788,921
Chocolate and cocoa	2,826	22,390,222	8,867,162
Baking powder and yeast	2,135	20,774,588	11,436,603
Dyestuffs and extracts	2,397	15,954,574	6,279,923
Blacking, cleansing and polishing preparations	2,417	14,679,120	7,716,728
Wood distillation other than turpentine	2,721	9,736,998	3,861,147
Oleomargarine	406	8,147,629	1,650,997
TOTALS	513,020	$2,605,262,886	$829,032,389
TOTAL FOR 31 CHEMICAL INDUSTRIES	1,042,843	$5,060,298,015	$1,726,740,885
TOTAL FOR ALL INDUSTRIES	6,615,046	$20,672,051,870	$8,529,260,992

AMERICAN INDUSTRIES VS. COAL-TAR DYES.

A most liberal estimate of the market value of the world's entire production of coal-tar dyes places it under $100,000,000; the entire consumption in the United States is less than $15,000,000, duty included, and this amounts to about 15 cents per person per year.

Now, which would you rather have, these thirteen industries with their $2,500,000,000 worth of manufactured product or the coal-tar industry with its $100,000,000 worth of product? The number of persons employed in these above thirteen industries is in excess of 500,000; the entire world's supply of coal-tar dyes is made by fewer than 40,000 people. Which would you rather have?

These thirteen industries employ 8 per cent of all wage-earners in manufacturing enterprises in the United States, produce 12 per cent of the total value of manufactured product, and 10.5 per cent of the total value added by manufacture. In other words, the chemist engaged in these thirteen pursuits plays an important, if not indispensable, part in the lives of 8 per cent of our wage-earners, and affects 12 per cent of our manufacture-values and 10.5 per cent of our values added by manufacture. But the total number of chemists makes up only about 0.01 per cent of the population of the United States.

NO NATION CAN DO EVERYTHING ITSELF.

Of course, it may be said that having made all these other things, there is no excuse why the American should not make coal-tar dyes in addition. Perhaps so; but nations, like individuals, cannot each have or do everything. If each nation could do everything equally as well as every other nation, there would be no occasion whatever for international business. As this world is constituted, each nation does that which it can do the best and trades off the product for what some other nation can do better than it, and both sides are satisfied and make a profit; this is the same as the relationship between individuals. The shoemaker can make shoes better than he can bake bread; he makes shoes and exchanges part of his income with the baker for bread which the baker has made.

If American chemists can operate these industries better than or as good as other nations, it is no real ground for criticism that they cannot do everything better than any other nation, no more than the shoemaker is to be criticised because he cannot make as good a suit of clothes as the tailor. If you want the shoemaker to be able to make a suit of clothes as well as the tailor you must provide him with the opportunity to learn how to tailor and take care of him while he is learning, and no doubt his suit of clothes will cost him more than it would cost an established tailor to turn out the same kind of a suit of clothes, and you must again help your shoemaker while he is trying to market his suit of clothes against the established tailor.

EIGHTEEN ADDITIONAL AMERICAN CHEMICAL INDUSTRIES.

The above nineteen American industries referred to by no means comprise all the American industries in which the chemist can be of help and assistance. Many more are open.

A search through the census for 1909 discloses the eighteen additional industries listed in Table Ib which make use of chemists in the control of their operations.

In these eighteen additional industries the chemist affects 8 per cent of our wage-earners, 12.6 per cent of our manufacture values, and 9.7 per cent of our values added by manufacture. For these thirty-seven industries, then, the 0.01 per cent of chemists of our population directly affect 16 per cent of our wage-earners, 24.6 per cent of our manufacture values, and 20.2 per cent of our values added by manufacture.

This, therefore, is a measure of the influence of the chemist upon the industrial development of the United States; however gratifying this result is, it is nevertheless true that many other industries could employ chemical control to great advantage, if they only would, and many establishments under the above cited industries could, if they would, make use of chemical control. There is plenty of work left for the chemist to do in these industries to keep him fully and profitably engaged. This being so, why should he not continue to direct his energies to improving those things that he already can do, rather than attempt new and exotic things which others can do better than he?

THE FOREIGN BUSINESS.

So much for our internal relations. How about our international relations? To answer this question I will use the official classification of the German government as to what constitutes products of and for chemical industry and also the same government's corresponding figures for 1913.

No two countries, speaking through their statistical departments, have the same working definition of chemical industry. None of the official classifications is as comprehensive as is the official German classification. So far as the exchange of products and commodities involved in chemical pursuits is concerned, the German classification shows a total of 443 items, of which 230 are involved in international trade between Germany and the United States. According to these figures and this classification, the United States imported from Germany in 1913, $60,860,880, and exported to Germany $156,086,690, or a total business of $216,896,970, with a balance in favor of the United States of $95,175,810. I have selected from this 1913 list of items of business between Germany and this country those whose gross is $400,000 per annum or over (Table II).

It is interesting to note that we sell Germany more lard than Germany sells us of potash and alkalies and other coal-tar dyes put together; that we sell Germany

* An address before the American Chemical Society at its fiftieth meeting, New Orleans, March 31st-April 3rd, 1915. From The Journal of Industrial and Engineering Chemistry.

half again as much refined petroleum as it sells us aniline and other coal-tar dyes; that we sell Germany practically the same amount of pig and scrap lead as Germany sells us of alizarin and anthracene dyes; that we sell Germany almost as much paraffine as Germany sells us of indigo; and so on through the list.

TABLE II—U. S. CHEMICAL TRADE WITH GERMANY (1913)

U. S. imports from Germany	Value in U. S. money	U. S. exports to Germany
	$74,000,000	1 Copper
	26,700,000	2 Lard
1 Potash salts	18,819,000	
	17,490,000	3 Refined petroleum
2 Aniline and other coal-tar dyes	7,290,000	
	4,970,000	4 Phosphate rock
	4,890,000	5 Oleomargarine
	4,340,000	6 Turpentine resin
	4,460,000	7 Mineral lubricants
	3,600,000	8 Spirits turpentine
3 Caoutchouc	2,487,000	
	2,220,000	9 Crude benzine
	2,171,000	10 Beef tallow (prime)
	1,744,000	11 Nickel and nickel coin
	1,649,000	12 Cotton-seed oil
4 Straw, esparto and other fibers; paper stock	1,590,000	
5 Alizarin and anthracene dyes	1,463,000	
	1,421,000	13 Pig lead and scrap
6 Indigo	1,319,000	
	1,231,000	14 Crude and hard paraffin
	1,162,000	15 Acetate of lime
7 Platinum and allied metals	1,120,000	
8 Hops	982,000	
9 Miscellaneous volatile oils	941,000	
	903,000	16 Tin and tin scrap
10 Tin and tin scrap	900,000	
11 Potassium and sodium cyanide	843,000	
12 Chrome, tungsten, etc.	784,000	
13 Superphosphates	766,000	
	724,000	17 Crude wood alcohol
14 Beet sugar, refined	716,000	
	695,000	18 Carbides
	673,000	19 Miscellaneous volatile oils
15 Alkaloids compounds	672,000	
16 Toilet and tooth powders	658,000	
	656,000	20 Heavy benzine and patent naphtha
17 Lime-nitrogen, etc.	635,000	
18 Potash carbonate	632,000	
	617,000	21 Lubricants of fats and oils
	579,000	22 Beef and mutton tallow
19 Ferro-Al, Cr, Mn and Ni	567,000	
20 Potassium magnesium sulfate	509,000	
21 Gold ores	508,000	
	506,000	23 Copper alloys
22 Beet sugar, raw	492,000	
23 Aniline oil and salt	476,000	
24 Bronze and metal colors	473,000	
25 Glue	471,000	
26 Aluminum plates and metal	464,000	
27 Quinine and its salts	434,000	
	422,000	24 Portland cement
28 Terpineol and allied synthetics	405,000	
29 Gelatin	402,000	

RELATIVE QUALITIES OF IMPORTS AND EXPORTS.

Of course, it will be contended that the things that we sell Germany are, from a chemical point of view, less refined, i. e., involve less hard chemical intellectual work than do our imports from Germany. But, is most of the potash, which is practically mined from the ground in Germany, any more of a refined product than the phosphate rock we sell them? Does it not involve quite as much chemical ingenuity to produce good illuminating oil from petroleum as it does to produce many of the coal-tar dyes? There is no question that the general position above outlined is correct, namely, that our products, as a whole, are less refined than those that we get, as a whole, from Germany, but is that not true practically throughout our entire export and import business? Are not the textiles we export of a lower grade than those we import? Are not our leather products less refined than those we buy? And so on down the list. That being so, why pick out the chemist as a special mark for criticism when he is at least up to the average of his surroundings?

In 1913 the total foreign business of the United States amounted to $4,227,348,909, and the excess of exports of all kinds over imports of all kinds amounted to $691,271,949.

The trade in chemicals and products of and for chemical industry between the United States and Germany in 1913 furnished 5 per cent of that total of international business and provided 13.8 per cent of the balance of trade.

THE INFLUENCE OF THE CHEMIST.

The symposium of papers presented to-day constitutes a record of proud achievement, of solid accomplishment in nineteen different branches of American industrial activity, to which advance the application of chemical knowledge, chemical principles, and chemical experience by American chemists has contributed a noble share and an effective part. It is perhaps true that much of that progress would have come without the American chemist, but it is equally true that under those conditions the advance would have been much slower and also much of what has been accomplished would never have happened at all without the faithful, enthusiastic and alert co-operation of the American chemists on the job. With such a record, the American chemist can hold up his head with pride and self-confidence, firm in the belief, and warranted in his conviction that he has done a man's work, in a man's way, that he has not been an idler, nor a sloth, nor a drone, but that he has been one of the busiest of busy workers, with a keen eye and an alert intellect, always searching for an opportunity for the betterment of his industry, and for improvement of the conditions of his fellowman.

GERMAN SUPREMACY.

That the chemist has not done more is by no means due to any unwillingness. It is due in the largest part to the apathetic attitude of those in charge of the management of many of our industrial enterprises requiring chemical knowledge in their exploitation. Many of these men in responsible positions do not have a chemical education even along the lines in which they are financially active. In those cases chemical novelties and chemical problems are not passed upon, on their merits, by chemists or by men with a chemical point of view, but by merchants, by lawyers and by bankers, men who, by their very training, are not capable of taking the chemist's point of view, of having the chemist's sense of proportion, and are unwilling to take a chemist's chance in a chemist's way. Therein lies, perhaps more than in any other one thing, the reason for Germany's supremacy in most of the branches of chemical industry. That also is the reason for the success of a great many of our own huge transportation, electrical, and chemical enterprises. The business is run by men who know it from the technical point of view. Railroads are run by men who know the railroads from the operating and construction point of view; electrical enterprises by men who know the business from the electrical engineer's point of view, and they make their enterprises take their business chances in a transportation, and in an electrical way. Practically all of our chemical enterprises that have been managed in the same manner have also been successful, but there is still great room for improvement, and just as soon as that improvement is accomplished, just so soon, and no sooner, will there be less and less talk about the incompetency of the American chemist. German chemical enterprises are run and managed by chemists.

THE RESPONSIBILITY OF THE CHEMIST.

The chemist must not attempt to absolve himself from all responsibility for the prevailing lack of appreciation or skepticism among capitalists and bankers of the value of chemical work in industrial operations. While competent chemists and chemical engineers by their very effective work have wrung from reluctant financial men proper acknowledgment of the value of chemical examination, control, and management of enterprises requiring such, yet the work has not gone far enough, and it is not at all unusual for financial men to support with might and main enterprises which any qualified chemist or chemical engineer could and probably did tell them were foredoomed; also it must not be forgotten that qualified chemists and chemical engineers, like other professional advisers, have gone astray in their calculations and have supported enterprises which ultimately failed. The mining, electrical, and railroad engineers finally succeeded in obtaining their present influential position among the industrial councils of this country, and with the brilliant success of the chemical engineers of Germany in the same direction it is not too much to hope that ultimately the American chemist and chemical engineer will come into his own. When he does, there will be far fewer exploitations than heretofore of the wild and fantastic schemes of chemical enterprise now so easily financed by the gullible portion of our investing public and fewer and fewer failures of chemical enterprises undertaken in good faith and serious mood.

Therefore, let every chemist in advising on chemical operations prominently bear in mind that failure to give correct advice not only reacts upon him but upon each and every member of the chemical profession and merely helps to postpone the day when the chemist will come into his proper position among the makers of the nation.

CONGRESS AND CHEMICAL INDUSTRY.

Like every other industry, all the branches of chemical industry are dependent for their ultimate success upon economic conditions. They must be able to sell at a price greater than their costs. It is not enough to have the material, the men, and the "know how"; you must have the market as well. However, the attitude of consumers of chemicals in this country has habitually been opposed to the creation in this country of conditions favorable to the manufacture of chemicals.

The following quotation from an address in 1910, by Dr. W. H. Nichols,[1] presents this aspect of the problem completely.

"If a comparison were made between the chemical industry of this country and that of other countries, it would be found that the industry in this country in most respects is fully on a par with that of any other country, and in some respects is well in the lead. It is a public notion that our industry is coddled by the tariff, and is thereby based upon a somewhat insecure foundation. Like many other public notions, this is not true. It will be seen by casual examination of the imports that there are a number of chemicals which are not made in this country at all, and a number of others which are made only to a moderate extent. This is not due as much to lack of enterprise of the chemical manufacturers as the fact that the tariff is distinctly unfavorable to the manufacture of many chemicals which are produced in Europe on a large scale and whose manufacturers use this country as a "dumping ground." In our tariff all chemicals, unfortunately, are enumerated in Schedule "A." It has been the history of several revisions of the tariff that these revisions have been approached with a firm intention on the part of our legislators to lower the tariff, and they have begun on Schedule "A" with a great deal of enthusiasm. The rates of duty of this Schedule have been steadily reduced, and many articles placed upon the free list before the log-rolling, which is popularly supposed to form such an important part of all tariff inquiry, has begun to get in its work; hence the chemical industry has met with constantly lower tariff rates, while the materials which it has to use have often been left in a position unfavorable to chemical manufacturers. In the interest of fair play, it is to be hoped that when the tariff shall again be revised our legislators will begin at the other end of that document.

"I think it may be stated safely that the chemical manufacturers of this country do not ask and have not asked any favors of the people which would result in any way in a fictitious advance in the values of their output. It is also fair to state that the chemical manufacturers of this country, while entirely friendly to one another, are in no way connected by agreements or 'pools.' While there may be exceptions to this of which I am not aware, I think this can be put down as a general statement, and I am sure it will be believed by all consumers of chemicals who come in contact with the active salesmen of the numerous companies."

It is, therefore, only fair to say that the American chemist and chemical manufacturer has throughout made the most of his opportunities, has made his fair contribution to the country's need and growth, and has taken a fair and proper share in the internal and international business of the United States. The people of the United States, speaking through Congress, have repeatedly told the American chemist and the American chemical manufacturer "so far and no farther will we help you." The chemist and manufacturer have done all that can be accomplished under those circumstances; if they could not attract capital to all the enterprises they desired to found it was for the reason that capital could be more profitably employed otherwise and money has the stubborn habit of going where it can obtain the biggest return—long waits and uncertain results have no attractions for it.

(*To be continued.*)

[1] *J. Soc. Chem. Ind.*, 29 (1910), 1448.

Tincture of White Soap*

It is assumed that when a surgeon is washing up, in preparation for an operation, the aim is to thoroughly cleanse the skin and to remove all grease and other matters which are liable to entangle or harbor bacteria. For this purpose, soft soap is generally employed, either as such or as made up into tincture of green soap, or other similar alcoholic solutions.

Three objections to soft or green soap appear, viz.: (1) It carries much free alkali, which tends to roughen the skin; (2) it has a disagreeable odor, often masked by the addition of oil of lavender or carbolic acid; (3) it clings to the skin and cannot readily be so completely removed that no odor is left.

With the aim of preparing a liquid soap which will not carry these objections, I sought to substitute for this use white castile or Marseilles soap. This soap is soluble in about 9 parts of cold water and in about 17 parts of alcohol, which solutions are far too dilute for the use in question.

"White soap," however, is soluble in about two parts of dilute alcohol, and the addition of a little ammonia further increases this solubility, so that with it we can obtain a solution containing as much true soap as is present in an equal volume of tincture of green soap. (Note that green soap, as sold, retains the glycerine of the oil and much water.)

The name and formula proposed for this preparation is as follows:

TINCTURE OF WHITE SOAP.

			For 1 gallon.
℞	Of white soap, Conti's	300 gram.	1,200 gram.
	Of ammonia stronger	25 c. c.	100 c. c.
	Of alcohol	350 c. c.	1,400 c. c.
	Of water, dist.	325 c. c.	1,300 c. c.

The specific gravity of this is 0.97, which is identical with that of tincture of green soap.

To make one gallon: Mix the liquids for it in one gallon jar and then add the soap, previously cut into coarse shavings. Crowd all the soap into the jar and cover it with a glass plate. After 12 hours stir, and again stir after some hours. Allow to settle 12 hours and then filter, decant or syphon off the clear liquid into a can which may be kept closed. There will remain a few ounces retaining the impurities of the soap, which may be used for less particular washing. If this liquid is exposed to evaporation for a few hours, ammonia and alcohol escape, and a mass of the consistency of green soap will be obtained.

This form of soap alone has been employed by the surgeons in the University Hospital for the past year or more. While this preparation is free from the three above mentioned objections to tincture of green soap, it presents the additional advantage of costing but $1.50 per gallon, and, if the alcohol be obtained tax free, the cost will be about 60 cents per gallon, while tincture of green soap will cost one dollar or more.

* Read before the Medical Section of the Philosophical Society of the University of Virginia.

Fig. 1.—Loading a sherardizing drum.

Sherardizing for Rust-Proofing Metals*

The Process, the Apparatus and Methods Employed

By Chester L. Lucas†

Fig. 2.—Charging one of the furnaces.

NUMEROUS processes are employed for rust-proofing metal articles. Of these one general class is based on the application of a coating of zinc to the work. Of the zinc-coating processes, the oldest in common use is undoubtedly hot galvanizing. This is essentially a dipping operation in which the work, after being properly cleaned, is immersed in a tank of molten zinc. Another method of rust-proofing is the electro-galvanizing process which had its inception before hot galvanizing, but only until within the last few decades has it come into use. This is an electro-plating process, in which zinc is deposited from an anode onto the work. In addition to these two processes, there are others based on the immersion of the work in solutions of different kinds, and at least one in which the zinc dust is sprayed on the work while hot. Another zinc-coating process is sherardizing and it is the purpose of this article to outline the practical side of this interesting process.

THE SHERARDIZING PROCESS.

The sherardizing process was originated in England by Sherard Cowper-Coles about 12 years ago. Briefly, the process consists in sealing the work to be sherardized in metal retorts in conjunction with metallic zinc dust. The retorts are then heated until the work at the center has reached a temperature of from 500 to 700 deg. Fahr., depending upon the nature of the work; at the same time the retorts are turned intermittently so as to give the zinc dust access to all parts of the work. After holding this heat for several hours, the time depending on the thickness of the coating desired, the drums are taken from the furnace and allowed to cool. When cool the work is finished. The sherardizing process can be applied with advantage to a great variety of articles, however intricate. These range from a watch screw to a roll of wire fencing. A sherardized surface is light gray in color, and the finish imparted is a fine matted surface resembling that obtained by sand-blasting. Fig. 3 shows a sherardized surface magnified 70 times which accounts for the rough appearance.

The action that takes place in sherardizing consists in forming both a zinc-iron alloy and a coating of zinc upon the material to be treated. The zinc dust becomes partially vaporized under the influence of the heat applied, and the vapor thus produced in condensing upon the hot iron forms the protecting coating, the inner layers of which alloy with the iron, while the outer layers provide additional surface protection of nearly pure zinc. Fig. 4 will perhaps make this point clear. This shows a section through a piece of low-carbon steel that has been sherardized. This has been magnified 1,300 times and plainly shows the body of the steel, the zinc-iron alloy section and the pure zinc coating above. It should be explained that this photograph was taken of a section formed by cutting through the stock and polishing the surface.

* From *Machinery*.

† Associate Editor of *Machinery*.

ADVANTAGES OF THE SHERARDIZING PROCESS.

Sherardizing has advantages over other methods of zinc coating, which may be classed under two heads; first, the superiority of the product and second, the economy of the process. The fact that the zinc coating penetrates unlike any other method of zinc coating, and amalgamates with the iron, makes a finish that cannot be worn or eaten away. In addition, the coating is so evenly applied and so thoroughly driven into the surface of the metal that it does not alter the exterior of the article to any appreciable extent. In fact, sherardizing is perfectly practical for the protection of threaded screws of fine pitch and it is not not necessary to recut them after the coating has been applied if a slight clearance is made when cutting the thread. Because of the nature of the process every part of the article treated is reached, the insides of tubes or sharp corners are coated just as thoroughly as the more exposed places. The depth of the coating may be controlled by the metallic percentage of the zinc dust, the length of time the heat is applied and by the temperature to which the retorts are subjected. There is no distortion of slender pieces or thin objects such as might occur when using the hot dip, because in sherardizing the heat is applied gradually and the work just as slowly cooled off.

The economy of the process is at once evident by the low heat required, the temperature of 500 to 600 deg. Fahr. being far below the melting point of zinc, which is 786 deg. Fahr. Less zinc is required because none is wasted. The thin but thorough coating that is applied is just as effective as the thick rough coating that the hot galvanizing process gives. A sherardized coat of one-half ounce to the square foot affords more protection than a galvanized coating of 1¼ ounce to the square foot. No flux is necessary and the presence on the work of non-fatty oil in a moderate degree does not interfere with the sherardizing.

There is practically no limit to the metallic products that may be sherardized; in fact any articles that may be placed in the drum may be so treated. Oftentimes drums of special shape may be made to accommodate certain products. Screening, wire, etc., may be handled just as effectively as inflexible material by coiling it and placing it in that state in the drum. After sherardizing, the wire or screen may be straightened without injury to the coat of sherardizing.

Practically the only limitation to the sherardizing process is the fact that on very small tempered steel articles such as springs, the heat of 600 degrees or thereabouts will draw the temper, leaving the metal in an annealed condition. On most work, however, this is not objectionable.

The process of sherardizing is not confined to the coating of the product with zinc alone, but aluminum, tin, etc., are also used for sherardizing to good advantage. Zinc, however, is the leading metal on account of its ability to resist corrosion, due to its being electro-positive to iron.

ZINC FOR SHERARDIZING.

The zinc dust used in the process of sherardizing is commercial zinc dust, of which at this time about 90 per cent is imported. On an average, the composition of this material runs about 90 per cent metallic zinc and 10 per cent zinc oxide. Zinc dross is sometimes used, but not very successfully, as it will not alloy with the work being treated as intimately as the finely powdered zinc dust, although when the two are combined in equal parts they show good results. The best results are obtained when the zinc dust has been reduced to about 50 per cent metallic by the addition of spent zinc; therefore, new zinc should be reduced to that percentage as rapidly as possible.

Sherardized material require a deposit of 4 pounds of zinc per 100 pounds of material treated, as an average. After the zinc has been reduced to the right percentage it may be held at that strength by simply replacing 4 pounds of new zinc for every 100 pounds of material treated, taking care that it is thoroughly mixed with the spent zinc dust. A chemical analysis of the dust in use once a month is recommended.

CLEANING THE WORK.

Sherardizing, like other zinc-coating processes, should have a clean surface to work upon. The presence of scale, rust or dirt greatly interferes with the sherardizing

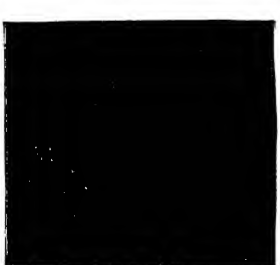


Fig. 3.—Appearance of a sherardized coating, magnified 70 times.

Fig. 7.—Turning the drums.

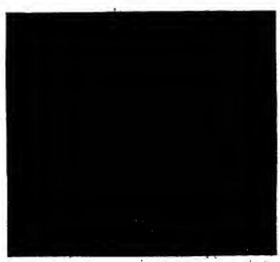


Fig. 4.—Enlarged cross-section photographed through a piece of sherardized steel magnified 1,300 times.

action. Machine products like screws and bolts require no cleaning other than an alkali dip. Sand-blasting is employed for cleaning relatively large pieces and an acid pickle is the common medium for removing scale. After cleaning with acid by the pickling process, the work should be thoroughly neutralized by placing it in a boiling solution of cyanide (mixture, 1 pound cyanide crystals to 20 gallons of water). A bright coating of zinc is assured, by taking these precautions.

The claim has been made that articles coming direct from the machine covered with oil can be sherardized without cleaning. This is true where no fats are used with the oil, and the zinc dust is new and of sufficient metallic strength to force itself through the oil. However, experiments along these lines have proved that after several operations, the material will come out very dark; therefore, considering the small cost of cleaning it should not be neglected.

PACKING THE DRUMS.

The drums in which the work is packed with the zinc dust may be of any convenient shape and size to fit the furnace in which the work is to be done. The one shown in the illustration Fig. 4 is 4½ feet long and 15 inches inside diameter. These are made of boiler plate with flanges at each end, upon which the end caps are bolted. In the event of the work being too long for the drum, two of these drums may be bolted together, making an extra long drum. The operator shown in Fig. 1 is loading the drum with chains which he takes from the barrel that may be seen at the right. In the drum shown, about 350 pounds of chain may be accommodated. The drums are filled in the same manner that a casehardening heat is prepared, first a shovelful of the zinc dust and then a shovelful of work is placed in the drum, and so on until the retort is filled to within about 2 inches of the top. This space is left to provide for expansion of the contents.

After the heads have been bolted on the drums, they are ready for the furnace. Fig. 2 gives an adequate idea of the way a sherardizing furnace is charged for firing. The laborer who fills the retort, loads them upon a skeleton truck, the top of which has a cross track from which the drums may be rolled into the furnace by means of wheels slipped over their ends. It will be noticed that the drums are spaced and held by an angle iron frame. This view shows the square sockets in the drum-caps, by means of which the drums may be turned while the sherardizing is going on.

THE SHERARDIZING FURNACE.

The requirements of a furnace for sherardizing are not severe. On account of the fact that the maximum heat required to be imparted to the work is only from 500 to 700 deg. Fahr., illuminating gas, natural gas, oil, coal or even coke may be used. The New Haven Sherardizing Company is paying special attention to coke furnaces. In other lines of work coke furnaces have not been in general favor on account of the low amount of heat to be derived from this fuel, but as coke will give a sufficient heat for sherardizing, the economy of the coke furnace is apparent.

Figs. 5 and 6 show a new coke furnace made by the New Haven Sherardizing Company, for the purpose of sherardizing. This is a coke-burning furnace, although it can be used for soft coal or, in fact, any other fuel. It is especially valuable in urban districts where no liquid or gaseous fuel is available. The operating cost of this furnace is practically the same as for natural gas or producer gas. As Fig. 6 shows, it is made on the arch construction plan, employing a double arch. One of these arches is over the work chamber or oven and the second arch, which is larger, embraces the first arch and

Fig. 5.—A coke burning sherardizing furnace.

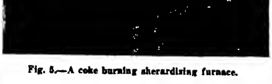


Fig. 6.—Section through the coke burning furnace.

also the coke burning pocket at the side. Near the center of the arch over the work chamber, there are a number of rectangular openings. The heat passes up from the coke pocket to the top of the large arch, and is drawn downward through the rectangular openings into the furnace and onto the work. Each of those several openings is controlled by a separate damper whose handles may be seen at the left-hand side of the furnace in Fig. 5.

The furnace has an automatic drum turning feature which provides for the turning of the sherardizing drums at stated intervals. Intermittent turning of the sherardizing drum gives better results than the continuous rotation practice that has been advocated by some authorities. The work is much cleaner and brighter if not continuously rotated during the sherardizing process. In those plants where continuous rotation is practised, the drums are turned one revolution every two minutes. When turned by hand intermittently, the operation is performed as shown in Fig. 7. Short squared shafts extend through the furnace wall and into the sockets in the ends of the drums. Every 15 minutes the drums are given a half turn to mix the contents thoroughly and allow the heat and zinc to have access to all parts of the work. From the above, it will be seen that there are three methods in vogue for turning the sherardizing drums while under heat: viz., continuous rotation, automatic intermittent turning and intermittent turning by hand. Above the squared shafts shown in Fig. 7 may be seen the pyrometer that indicates the furnace heat

The temperature at which the furnace is kept varies according to the size of work being sherardized. From 500 to 700 deg. Fahr. marks the range limits, large work requiring the higher heat. The drums are kept heated for a period varying from 4½ to 5 hours, according to the depth of the sherardizing coat that it is desired to give the work.

REMOVING THE WORK.

At the end of the prescribed time that the drums are kept under heat, they are rolled out of the furnace and allowed to cool slowly until they may be handled without inconvenience. For the unloading operation the drum is hoisted to the mouth of a rotary screen and there emptied, the contents passing through the rotary screen. The work emerges at the outer end, while the zinc dust drops through the screen and out of the way. It will be seen that the mouth of the screen leads out of a forge-like structure that catches the work as it is pulled from the drum and allows the floating dust to be carried away in the exhaust overhead. The work emerging from the farther end of the screen is caught in a second screen and the process repeated until at the end it is perfectly clean and free from all zinc dust.

THE COST OF SHERARDIZING.

There are four charges that enter into the cost of sherardizing. First is the royalty that must be paid to the owners of the process, second the labor cost, third the cost of the zinc dust and fourth the fuel charge. The royalty is in all cases approximately $2.50 per ton of material sherardized. The cost of the zinc dust required for a ton of work varies with the size of the work but is approximately $5, based on the use of 80 pounds of dust at 6¼ cents per pound. The labor cost for handling a ton of average work would be about $3. The fuel cost varies, being for producer gas $1.75 per ton, for illuminating gas $4 per ton, for natural gas 75 cents per ton, for crude oil 90 cents per ton and for coke 75 cents per ton. From these figures it will be seen that expense is no barrier to the use of this most efficient of rust-proofing processes

London Traffic Dangers

WITH the continued absence of effective measures of control and for the relief of congestion, London's traffic problem steadily increases in complexity, and, unhappily, the tale of street accidents as steadily grows. Statistics published in the annual report of the London Traffic Branch of the Board of Trade, issued recently, show that in the last decade accidents caused by road vehicles in the metropolitan area have more than doubled, and that the proportion to population is continuously rising.

It is true that people travel much more than they used to do. In 1904 the journeys per head of the population were only 150.5; in 1913 they were 271.5, an increase of 80.7 per cent. But the corresponding totals of street accidents were 11,907 in 1904, and 25,839 in 1913, an increase of 115.9 per cent. Fatalities in particular have become much more numerous, and there can be no doubt (says the report) that this is largely due to the multiplication of motor vehicles.

In 1913 power-driven vehicles again caused some 2,000 more accidents than in the preceding year. Nor was the previous decrease maintained in those caused by horse-drawn vehicles, an actual increase over 1912 being shown in 1913. In the four years 1910-13, 45,366 accidents were caused by power-driven vehicles, and 43,077 by other vehicles, including cycles.

Three per cent of the accidents due to power-driven vehicles in 1913 proved fatal, and 2⅜ per cent in the case of horse-drawn vehicles. That this is largely due to weight is shown by the relatively high percentage of accidents in the case of the heavy motor car and the motor 'bus, with 8.7 and 5.4, respectively. On the other hand, the electric tram, the heaviest vehicle of all, with its low percentage of 1.6, is an exception, and this is accounted for by the high efficiency of the lifeguard, which has been the means of saving many lives.

While the motor 'bus still heads the list with the largest number of deaths—656 in the four years—the danger of these vehicles, in proportion to the work done, has largely decreased. There is no doubt that the fitting of the side wheelguard has had a very beneficial effect in checking the number of accidents, and the latest returns go to show that the improvement was still more marked in 1914.

Investigation proves that as a whole power-driven vehicles are twice as dangerous as horse-drawn vehicles, while the cycle is slightly less dangerous than any other type of vehicle. As regards causing death, the differences are much more marked. The cycle is by far the least fatal, and considered as the unit to which the other vehicles are referred, the electric tram and horse vehicles come next, being nine times as fatal, the motor cab eleven times, motor cars twenty-three times, and motor 'buses thirty-eight times as fatal as the cycle.

It is added that setting up of a large number of additional refuges, and the compulsory fitting of guards to the sidewheels of all motor omnibuses have already done much, and will do more, to check the rate of increase in accidents. It would also be advisable that the heavy commercial motor cars now in use should have similar guards fitted, but in view of the fact that the average of the three years 1910-12 showed that 55 per cent of the fatalities were due to the inadvertence of the pedestrian, the best hope of further improvement seems to lie with the pedestrian himself, and there is no doubt that the average person is now much more careful than he used to be.

In 1913 the number of passengers carried by railways, tramways, and omnibuses in the London area reached the colossal total of 2,007,348,055. Of these 462,010,537 were railway, 811,307,317 tramway, and 733,-031,201 omnibus passengers. The total represents 271.5 journeys per head of the population. In 1903 the aggregate was 972,465,082, equivalent to 144.9 journeys per head. In addition, cab journeys in 1913 are estimated at over 50,000,000.

Horse drawn vehicles continue to be supplanted with remarkable rapidity by those mechanically propelled, and the extinction of the horse for passenger purposes seems now almost in sight. Some years may elapse before this result is achieved among trade vehicles, but the motor is adding very largely every year to the importance of arterial communication by road. The observations show that in 1914 only 4 per cent of the passenger vehicles were horse drawn, compared with 6 per cent in 1913, 11 per cent in 1912, and 13 per cent in 1911, and that in 1914 85 per cent of the trade vehicles were horse drawn, compared with 88 per cent in 1913, 91 per cent in 1912, and 94 per cent in 1911.

As showing the growing inadequacy of the main arterial roads, it is stated that the total horse and motor vehicles enumerated at 84 points, fairly distributed all over London, increased in 1914 by 19.2 per cent over the figures for 1911. "The greater part of this increase occurs in the zone from six to nine miles from St. Paul's Cathedral, which is precisely the area where in it is of such absolute importance to deal with the question of road improvement without delay. The fact that estate development has already blocked some of the selected routes should convey a serious warning that there is no time to lose in dealing with other sections of roads on the outskirts, if exits from London, at present available, are to be saved from the same fate."
—*The London Daily Telegraph.*

The Zeppelin Question

Facts and Figures Indicating the Number and Capacity of the Air Fleet

So much has been said about the monster Zeppelin airships, what they were expected to do, what they have accomplished, and what use may be made of them in the future, that the following examination of the factors of these big craft by Georges Prade, published in *Le Journal* and translated by *Flight*, will be read with particular interest at this time. M. Prade's article is as follows:

The Zeppelin question has become to a certain extent—and, perhaps, entirely so—the question of the day. After not having believed sufficiently in the Zeppelin, there are now people who believe too much in it. Permit one, who has followed the matter from the first, and who has appreciated the splendid efforts of Count Zeppelin, to examine, figures in hand, and in the light of cold reality, the probable actual state of the German aerial fleet, the nature, value, and number of its units, the possibilities and the exact conditions of a raid on London or Paris.

The real offensive value of the German aerial fleet is the sum of efficiency and number of the units that compose it. Let us, therefore, establish these two points, and commence by defining what a modern Zeppelin is. The imagination has been given free play on this subject, and, as if the Zeppelins were not already monstrous enough, rumor has made them even larger. Some writers have gone so far as to talk of "super-Zeppelins" of 400 yards in length, which presumes a trifle of 300,000 cubic meters. It can be stated without hesitation that the modern German dirigibles are of the same tonnage as before the war, which is, of course, necessary for their rapid manufacture. Material proofs of this statement, of which the first, sufficient in itself, is the actual dimensions of the German sheds, are obtainable. The longest shed in Germany, that at Leipzig, is 183 meters, and those at the works of Friedrichshafen, which have not yet been enlarged, are 178 meters long. The rotatable shed at Cuxhaven, which cannot be enlarged, is 180 meters. Those at Cologne, Metz, and Baden are only 158 and 160 meters. The French *hangar* at Maubeuge has lately been enlarged to 160 meters by the Germans. The two 1914 types of Zeppelins measure: The 22,000 cubic meters army airship, length, 156 meters; diameter, 14.8 meters; width over the propellers, 23.5 meters; and height, 18.8 meters. The 27,000 cubic meters naval airship, length, 158 meters; diameter, 16.58 meters; width over propellers, 22.8 meters; and length, 19 meters. These figures represent, therefore, the maximum size airship which will enter the actual German *hangars*. It has been possible to improve their economy, but their tonnage, and consequently their radius of action, useful load, maximum attainable height, and speed are the same to-day as they were in July last. This radius of action is sufficient not only in times of peace, but also in war time, as evidenced by the Cuxhaven-Yarmouth-Cuxhaven raid. The length of this was 730 kilometers [453 miles], or equal to a cruise from Frankfort to Paris and back, or Cologne to London and back. Airships of the same type and carrying the same load can, therefore—theoretically, and speaking from the aeronautical point of view—repeat the performance, starting out from a sufficient number of sheds.

What are these airships? What weight of bombs do they carry? We know that the Germans have naval airships of a known type, and of 27,000 cubic meters capacity. Let us first attempt to calculate their load of explosives, as this will serve as a basis for the estimates of modern ones.

Let us state, first of all, that the lessons of experience (the bombardment of Antwerp, Ostend, Ghent, of the Belgian campaign, of Warsaw, Plock, Nancy, the English coast, and Libau) have up to now been very reassuring. In each case there was no real bombardment, and the cruisers of the air, which were the same in numbers as at Yarmouth (two or three) have dropped few bombs; bombs, moreover, which were of light weight and small effect. There were twelve deaths at Antwerp, not a single one at Ostend or at Ghent; forty deaths from five bombardments in Poland, two at Nancy, four in England. This gives a total of about sixty victims, that is to say, the crews of two large Zeppelins, all in six months of campaigning, and after fourteen attacks, during which period the flotilla lost at least five units. Nowhere have bombs been found weighing more than 50 kilogrammes [108 pounds] (this was the weight of the bomb found intact at Yarmouth).

The estimate of the useful load which a Zeppelin will carry will explain this mystery, which cannot be ascribed to Teutonic modesty.

The Germans have carefully withheld these figures from us. In the German *Taschenbuch* of the aerial fleets, the useful load of Zeppelins does not appear. We have, however, fairly exact data to go on. The first were furnished at the time of the landing of "Z-4" at Luneville in April, 1913. This airship was of the 19,500 cubic meters [23,505 cubic yards] type (141 meters by 14.8 meters—462.5 feet by 48.5 feet). The total lift was, therefore, about 20,500 kilogrammes [45,195 pounds], but the ship's books showed that the dirigible itself, framework, fabric, motors (three Maybach of 180 horse-power each, and each weighing 448 kilogrammes—988 pounds), *only left available a lift of* 4,800 kilogrammes [10,582 pounds], which works out at 23.9 per cent of the total load.

From these 4,800 kilogrammes must be subtracted 950 kilogrammes [2,094 pounds] for the crew (twelve men), and 135 kilogrammes [298 pounds] of gasoline and oil per hour, which makes, for a six hours' cruise (360 kilometers—224 miles), 810 kilogrammes [1,785.75 pounds]. Finally, in order to reach a height of 1,900 meters [6,234 feet], hardly a sufficient altitude, "Z-4" had to jettison 3,000 kilogrammes [6,612 pounds] of ballast. The "Z-4," therefore, had exhausted its whole useful lift in a six hours' cruise and covering a distance shorter than that from the nearest German shed to Paris or London and back, without counting projectiles, ammunition, armament, and *personnel*. It can therefore be stated that, except by flying very low, and thus running the risk of being brought down, the Zeppelins of the 19,500 cubic meters capacity or less, are unable by far to solve the problem.

It is for this reason that Germany in 1903 constructed types of 22,000 cubic meters capacity [28,775 cubic yards], 156 meters long [512 feet] by 14.8 meters diameter, that is *to say*, of the *same diameter as the older ones*, but with more ballonets (18 ballonets instead of 16). The power and weight of the motors is the same, as is also, for all practical purposes, the speed. Nevertheless, the weight of the gas chamber has been increased by two ballonets, and the following estimate can be made: The weight of the gas chamber and of the keel has been increased by about an eighth, a weight which has to be subtracted from the extra lift of 2,600 kilogrammes [5,732 pounds] furnished by the increase in cubic capacity. Further, the extra weight of fuel for four hours which is required in order to give the dirigible the necessary range of action for the raid in question (ten hours' cruise of 600 kilometers—373 miles) has to be subtracted. This is an addition of 540 kilogrammes [1,190 pounds], which brings the total weight of fuel up to 1,350 kilogrammes [2,976 pounds]. A crew of twelve men is insufficient, especially in view of the fact that the dirigible is to be fitted with machine guns and gunners. The 27,000 cubic meter type had twenty-eight men on board (the number of victims in the *catastrophes* that overtook "*L-1*" and "*L-2*"). *If*, in this case, we only take eighteen men, that would be an extra load for the crew of 500 kilogrammes [1,102 pounds]. Then we must subtract the weight of the machine guns, of their ammunition, of two searchlights, and of the sheet steel armoring for the motors, which is 2 millimeters thick and weighs 14 kilogrammes per square meter.

We therefore see that the 22,000 cubic meter type with full war equipment and bound for Paris or London cannot carry anything like a ton of explosives.

There now remains the 27,000 cubic meter [35,314 cubic yards] type, which has theoretically 6,000 kilogrammes [13,228 pounds] more lifting capacity. But it has a diameter of 16.58 meters [54 feet] instead of 14.18 meters, and is 158 meters [519 feet] long instead of 156 meters. It has four motors of 180 horse-power each instead of three, and a crew of twenty-eight to thirty. The first Zeppelin captured at Warsaw had thirty men on board. The expenditure in fuel increases by a tenth. The figures given by the Maybach Works, which are, however, a minimum, give 229 grammes [about 8 ounces] of gasoline per horse-power hour and 2.5 kilogrammes [5.5 pounds] of oil per hour for each motor.

The raid on the English coast represented, out and back, a distance of 732 kilometers [454 miles] and a cruise of more than twelve hours' duration, since the "L-3," the record breaker, with a maximum speed of 70 kilometers [44 miles] per hour, has never been able to do more than an average speed of 60 kilometers per hour, which will give, including the reserve of fuel necessary in case of wind, 14 hours' fuel, or 2,366 kilogrammes of gasoline and 140 kilogrammes of oil—a minimum of 2,306 kilogrammes [5,089 pounds].

Let us now work out these supplementary loads; 380 kilogrammes for the fourth motor. In the "L-2" there was one more boat. In the "L-3" the second rear *nacelle* has been enlarged and the central cabin and the keel retained; say another 500 kilogrammes. Increase in gas chamber 5/22nds, meaning at least 3,000 kilogrammes; increase in ballast take 500 kilogrammes. (The "L-3" had to leave eleven men of the ordinary crew on the ground in order to be able to increase the attainable height from 420 meters to 3,125 meters [10,250 feet], the Zeppelin record, established on May 16th, 1914. This gives an extra height of 2,700 meters climbed in 3 hours 30 minutes at the expenditure of a special discharge of 1,000 kilogrammes, including the weight of the eleven men of the crew.)

Weight of supplementary crew, 600 to 800 kilogrammes. Total, 6,100 kilogrammes, which, even by reducing the ballast and crew, gives us the same weight of explosives, 1,000 kilogrammes [2,204 pounds] at the most, transported it is true, a longer distance, 730 kilometers instead of 540 kilometers.

The large naval dirigibles which appeared over the English coast certainly had not 1,000 kilogrammes [2,204 pounds] of explosives on board, which is proved by the fact that they did not throw that weight. I do not suppose that they would have carried their bombs back to Cuxhaven. These weighed at the most 50 kilogrammes, and each carried at the outside twenty bombs. Other figures confirm this estimate. Six bombs were thrown at Antwerp, three at Ostend, five at Ghent, fourteen at Nancy (three airships were of the 19,500 and 22,000 cubic meter type), and let us suppose that there were thirty bombs to two dirigibles over England, and eighteen at Warsaw (these must have been naval airships, as the Russians captured thirty men on board). For a raid on Paris or London, the mean distance of which is shorter, this figure of 1,000 kilogrammes of explosives would therefore serve as a good basis.

Let us add that the maximum speed of the Zeppelins is about 72 kilometers [45 miles] per hour. The best performance is that of the "Z-VI" (19,500 cubic meters, 540 horse-power), Brunswick-Leipzig-Brunswick, 320 kilometers in 4 hours 40 minutes, which gives 68 kilometers [42 miles] per hour. (May 16th, 1914.) The greater ones are much slower.

There now remains to work out the number of the units which we have dealt with.

There were before the war thirteen Zeppelins, of which one was almost destroyed—the "Z-11," brought down at Thionville; the other nearing completion, the "Z-IX." They were, in the order of construction: "Z-II" (17,800 cubic meters), "Viktoria-Luise" (18,700 cubic meters), "Z-III" (17,500 cubic meters), "Hansa" (18,700 cubic meters), "Z-IV," which came down at Luneville (19,500 cubic meters), "Sachsen" (19,500 cubic meters), "Z-1" ("Ersatz II") (19,500 cubic meters), "Z-V" (19,500 cubic meters), "Z-VI" (19,500 cubic meters), "Z-VII" (22,000 cubic meters), "Z-VIII" (22,000 cubic meters), "L-3" (27,000 cubic meters), and "Z-IX" (22,000 cubic meters). The "Hansa" and "Viktoria-Luise" were all passenger-carrying airships belonging to the Delag Company, and the "Sachsen," their sister ship, had gone over to the navy in May, 1914. "L-3" belonged to the navy, the others to the army.

We can here add the "Schütte-Lanz," called "SL-2," of 22,000 cubic meters capacity, which had equaled the Zeppelins at the trials. We need not count two dirigibles, "M-4" and "M-1," and three non-rigid Parsevals, "P-4," "P-3," "P-2." The largest "M" is 13,000 cubic meters and the biggest Parseval 10,000 cubic meters, so that they simply do not exist as regards the cruisers we have in view.

This gives us, therefore, fourteen units at the declaration of war, of which two ("Z-II" and "Z-III") were quite out of date; two others (the "Viktoria" and the "Hansa") were equally unsuitable for the cruise we have in view, and besides very much the worse for wear. Five were of a type that was not suitable for so long a trip, but they may serve for bombarding frontier towns (these are "Z-IV," "Sachsen," "Z-I," "Z-V," and "Z-VI"), and finally four dirigibles of 22,000 cubic meters capacity ("Z-VII," "Z-VIII," "Z-IX," and "Schütte-Lanz 2"), and one of 27,000 cubic meters ("L-3"). These figures explain the material impossibility of every attack in August.

I can hardly believe that Count Zeppelin, a personal friend of the Kaiser, [illegible] will admit the ideal "Schütte-Lanz" [illegible]. The "SL-2" was already exiled at Liegnitz in [illegible], where it [illegible] from Leipzig on May [illegible]. [illegible] therefore, without [illegible], eliminate from our [illegible] the "SL-2" and its sister ship, the "SL-[illegible]" [illegible]

30,000 cubic meters capacity, which was in course of construction at Mannheim in August, and there have been no more of them.

Since then, it is known from an infinity of sources, *and on this subject there can be no possible doubt*, the Zeppelin works have built a Zeppelin every three weeks. Those who are astonished at this figure should remember that in 1913 eight Zeppelins were constructed (Nos. 15 to 22), which works out at one every six weeks, and that in May, 1914, there were opened at Potsdam works intended to double the output of those at Friedrichshafen.

The Zeppelin works have, therefore, actually constructed eight or nine dirigibles of new type since the outbreak of war. This makes a grand total of twenty-two units, of which thirteen have a capacity of from 22,000 to 27,000 cubic meters, the other nine remaining as above.

How many of them have been destroyed, and of what capacity were those destroyed? It is possible to ascertain the *certain* destruction of five Zeppelins: two in Russia (Warsaw and Libau), one at Dusseldorf, one at Badonvillers, one at Friedrichshafen. It is *possible* that five others have also been destroyed: one at Metz, one at Cuxhaven, a second one at Friedrichshafen, and two seen by our aviators stranded in the Ardennes in the month of August. There are besides *probable* accidents in the interior of Germany. For the rest we have no certainty.

There remain, then, at the most seventeen Zeppelins, at least ten, and probably twelve to fifteen, and it is not possible to ascertain how many of these can be counted as modern types of 22,000 and 27,000 cubic meters capacity, and 156 to 158 meters in length.

It is possible to state the certain destruction of two of the thirteen indicated above, that at Badonvilliers ("Z-VIII") and the one in course of construction at Friedrichshafen. The crew of thirty of the first unit destroyed by the Russians indicates a third one as almost certain. There remain then at the most, eleven Zeppelins capable of undertaking the expedition in question, and at least six, say, generally speaking, eight or nine. We find, then, that there are in existence and suitable for the raid which formed the object of this study, six to eleven dirigibles of from 22,000 to 27,000 cubic meters capacity and of 156 to 158 meters length, 14.60 meters and 16.58 meters diameter, with four screws grouped in two pairs on two *nacelles* in the axis of the keel and with central cabin. They have a mean speed of 60 kilometers per hour and a maximum speed of 72 kilometers per hour, and can travel with a load of 600 to 1,000 kilogrammes of explosives at a height of from 1,500 to 2,000 meters, according to the weather. Here we have, then, all the figures of the great adventure.

There is nothing very dreadful in it, especially if we consider the material impossibility of grouping them from the start for a collective raid, the absolute impossibility for them of arriving together when starting from different points, as before stated, and the no less absolute impossibility of successive attacks, once the adversary has been warned by the first dropping of bombs.

Some Questions of Evolution*

The Present Position of Natural Selection Considered

In the Darwinian era studies on variation and heredity seemed significant, mainly as a means of approach to the problems of evolution. The post-Darwinians awoke once more to the profound interest that lies in the genetic composition and capacities of living things as they now are. They turned aside from general theories of evolution and their deductive application to special problems of descent in order to take up objective experiments on variation and heredity for their own sake. This was not due to any doubts concerning the reality of evolution or to any lack of interest in its problems. It was a policy of masterly inactivity deliberately adopted; for further discussion concerning the causes of evolution had clearly become futile until a more adequate and critical view of existing genetic phenomena had been gained. Investigators in genetics here followed precisely the same impulse that had actuated the embryologists; and they, too, reaped a rich harvest of new discoveries. Foremost among them stands the re-discovery of Mendel's long-forgotten law of heredity—a biological achievement of the first rank which in the year 1900 suddenly illuminated the obscurity in which students of heredity had been groping. Another towering landmark of progress is De Vries's great work on the mutation theory, published a year later, which marked almost as great a transformation in our views of variation and displayed the whole evolution problem in a new light. In the era that followed, the study of heredity quickly became not only an experimental but almost an exact science, fairly comparable to chemistry in its systematic employment of qualitative and quantitative analysis, synthesis, prediction and verification. More and more clearly it became evident that the phenomena of heredity are manifestations of definite mechanism in the living body. Microscopical studies on the germ-cells made known an important part of this mechanism and provided us with a simple mechanical explanation of Mendel's law. And suddenly, in the midst of all this, by a kaleidoscopic turn, the fundamental problem of organic evolution crystallises before our eyes into a new form that seems to turn all our previous conceptions topsy-turvy.

To judge by its external aspects, individual development, like evolution, would seem to proceed from the simple to the complex; but is this true when we consider its inner or essential nature? The egg *appears* to the eye far simpler than the adult; yet genetic experiment seems continually to accumulate evidence that for each independent hereditary trait of the adult the egg contains a corresponding *something* (we know not what) that grows, divides and is transmitted by cell-division without loss of its specific character and independently of other somethings of like order. Thus arises what I will call the puzzle of the microcosm. Is the appearance of simplicity in the egg illusory? Is the hen's egg fundamentally as complex as the hen, and is development merely the transformation of one kind of complexity into another? Such is the ultimate question of ontogeny, which in one form or another has been debated by embryologists for more than two centuries. We still cannot answer it. If we attempt to do so, each replies according to the dictates of his individual temperament—that is to say, he resorts to some kind of symbolism; and he still remains free to choose that particular form which he finds most convenient, provided it does not stand in the way of practical efforts to advance our real knowledge through observation and experiment. Those who must have everything reduced to hard and fast formulas will no doubt find this rather disconcerting; but worse is to follow. Genetic research now confronts us with essentially the same question as applied to the evolutionary germ. The puzzle of the microcosm has become that of the macrocosm. Were the primitive forms of life really simpler than their apparently more complex descendants? Has organic evolution been from the simple to the complex, or only from one kind of complexity to another? May it even have been from the complex to the simple by successive losses of inhibiting factors which, as they disappear, set free qualities previously held in check? The last of these is the startling question that the president of the British Association propounds in his recent brilliant address at Melbourne, asking us seriously to open our minds to the inquiry: "Whether evolution can at all reasonably be represented as an unpacking of an original complex which contained within itself the whole range of complexity which living things exhibit?" This conception, manifestly, is nearly akin to the theory of pangenesis and individual development, as elaborated especially by De Vries and by Weismann. It inevitably recalls also, if less directly, Bonnet's vision of "palingenesis," which dates from the eighteenth century.

We should be grateful to those who help us open our minds; and Prof. Bateson, as is his wont, performs this difficult operation in so large and masterly a fashion as to command our lively admiration. It must be said of his picturesque and vigorous discussion that we are kept guessing how far we are expected to take it seriously, or at least literally. We have always a lurking suspicion that possibly his main purpose may after all be to remind us, by an object lesson, how far we still are from comprehending the nature and causes of evolution, and this suspicion is strengthened by the explicit statement in a subsequent address, that our knowledge of the nature of life is "altogether too slender to warrant speculation on those fundamental questions." Let us, however, assume that we are seriously asked to go further and to enter the *cul de sac* that Prof. Bateson so invitingly places in our way. Once within it, evidently, we are stalemated in respect to the origin and early history of life; but as to that, one form of total ignorance is perhaps as good as another, and we can still work out how the game has been played, even though we can never find out how the pieces were set up. But has the day so soon arrived when we must resign ourselves to such an ending? Are we prepared to stake so much upon the correctness of a single hypothesis of allelomorphism and dominance? This hypothesis—that of "presence and absence"—has undoubtedly been a potent instrument of investigation; but there are some competent students of genetics who seem to find it equally simple to formulate and analyse the phenomena by the use of a quite different hypothesis, and one that involves no such paradoxical consequences in respect to the nature of evolution. Are we not then invited to strain at a gnat and to swallow a camel?

But I pass over the technical basis of the conception in order to look more broadly at its theoretic superstructure. Is not this, once again, a kind of symbolism by which the endeavor is made to deal with a problem that is for the present out of our reach? Neither you nor I, I dare say, will hesitate to maintain that the primordial Amoeba (if we may so dub the earliest of our ancestors) embodied in some sense or other all the potentialities, for better or for worse, that are realised before us at this moment in the American Association for the Advancement of Science. But if we ask ourselves exactly what we mean by this we discover our total inability to answer in more intelligible terms. We cannot, it is true, even if we would, conquer the temptation now and then to spread the wings of our imagination in the thin atmosphere of those upper regions; and this is no doubt an excellent tonic for the cerebrum provided we cherish no illusions as to what we are about. No embryologist, for example, can help puzzling over what I have called the problem of the microcosm; but he should be perfectly well aware that in striving to picture to his imagination the organization of the egg, of the embryological germ, that is actually in his hands for observation and experiment, he is perilously near to the habitat of the mystic and the transcendentalist. The student of evolution is far over the frontier of that forbidden land, in any present attack upon the corresponding problem of the macrocosm.

Perhaps it would be the part of discretion to go no further. But the remarkable questions that Prof. Bateson has raised concerning the nature of evolution leave almost untouched the equally momentous problem as to what has guided its actual course. In approaching my close I shall be bold enough to venture a step in this direction, even one that will bring us upon the hazardous ground of organic adaptations and the theory of natural selection. I need not say that this subject is beset by intricate and baffling difficulties which have made it a veritable bone of contention among naturalists in recent years. In our attempts to meet them we have gone to some curious extremes. On the one hand, some naturalists have in effect abandoned the problem, cutting the Gordian knot with the conclusion that the power of adaptation is something given with organization itself and as such offers a riddle that is for the present insoluble. In another direction we find attempts to take the problem in flank—to restate it, to ignore it—sometimes, it would almost seem to argue it out of existence. It has been urged in a recent valuable work—by an author, I hasten to say, who fully accepts both the mechanistic philosophy and the principle of selection—that fitness is a reciprocal relation involving the environment no less than the organism. This is both a true and a suggestive thought; but does it not leave the naturalist floundering amid the same old quicksands? The historical problem with which he has to deal must be grappled at closer quarters. He is everywhere confronted with specific devices in the organism that must have arisen long after the conditions of environment to which they are adjusted. Animals that live in water are provided with gills. Were this all we could probably muddle along with the notion that gills are no more than lucky accidents. But we encounter a sticking point in the fact that gills are so often accompanied by a variety of ingenious devices, such as reservoirs, tubes, valves, pumps, strainers, scrubbing brushes and the like, that are obviously tributary to the main function of breathing. Given water, asks the naturalist, how has all this come into existence and been perfected? The question is an inevitable product of our common sense. The metaphysician, I think, is not he who asks but he who would suppress it.

Now, it is undoubtedly true than many adaptations, to cite Prof. Bateson once more, are "not in practice a very close fit." Even the eye, as Helmholtz long ago taught us, has some defects as an optical instrument; nevertheless, it enables us to see well enough to discern some food for reflection concerning adaptations among living things. And it is my impression that efforts to explain adaptations are likely to continue for the reason that naturalists as a body, perhaps influenced by Huxley's definition of science, have an obstinate habit of clinging to their common sense.

*Abstracts from an address by Prof. Edmund B. Wilson, President of the American Association for the Advancement of Science, before the Association at Philadelphia, December 14th, 1914.

Influence of Radio-Active Earth on Plant Growth—I*

Facts Indicated by Practical Experiments

By H. H. Rusby, Dean of the College of Pharmacy, Columbia University

Up to the time of the discovery of radium, anthracite coal represented about the highest known degree of stored energy. Radium is now believed to embody 360,000 times the energy of anthracite coal. The energy of radium is, however, of a totally different kind from that of coal. The energy of coal and other ordinary substances is exerted by the atoms of which they are composed; that of radium by the separation of these atoms into smaller bodies and the liberation of the energy of these particles.

Two hundred pound plots of early cabbage and pumpkins. No cabbage destroyed by cutworms.

Leaves of pumpkins in central plot without R. A. F., scarcely reach to man's knees. Cabbage in foreground.

As a result of this great difference radium can perform work only of a totally different character from that performed by ordinary substances. It is the dream of the physicist to discover a method by which the energy of radium can be exerted without this dissolution of its atoms, the effect of which would be revolutionary in the mechanical world.

These particles, "emanations," as they are known, are spoken of as "rays," notwithstanding that they are in reality matter, or substance.[1] They are so light that, even after long periods, the radium that is losing them cannot be seen to have lost weight. They are so numerous that, although constantly given off in vast numbers, it is estimated that it would require 2,000 years to exhaust one half of these rays in a particle of radium, and there is no way known by which the radium can be made to cease losing them. These emanations will accumulate in substances into which they enter, especially water, and will later be given off therefrom as they are from the radium, but while the substance still contains them and is giving them off, it is said to be radio-active, and it possesses, for the time, the valuable properties of the radium itself. This is especially true of water, as applied in medicine or to plants. It is to be noted that such emanations are not radium itself and do not contain radium; neither does the substance in which they are held. On the other hand, radium enters into various combinations with acids and these compounds may be dissolved in water and other liquids. Such solutions are radio-active, like those containing the emanations, and give off the emanations, but they differ from them in that they actually contain the radium metal. The bromide and the chloride of radium are the soluble compounds most used, the sulphate the principal insoluble one.

The rays given off are of different kinds, exhibiting different phenomena, having different velocities, penetrating different substances and for different distances and producing different effects on the bodies which they attack. They are distinguished as alpha, beta and gamma rays.

Two hundred pound plot of pumpkins with foliage reaching nearly to man's waist.

Since the general nature of living animal and vegetable protoplasm is identical, the question of influencing plant growth by the action of radium was at once suggested. Could it be applied to field crops so as to produce an increased yield? Could it be applied to crops suffering from animal or vegetable parasites, so as to kill the latter, as it kills cancer in man? Or, would the crops suffer more from such an application than would their diseases? If the application were found beneficial, would the amount of radium required for the purpose render the operation unprofitable? Or, seeing that the activity of a particle of radium goes on for centuries without any apparent diminution, would a single application to the soil permanently increase its agricultural productivity?

Plant physiologists, all over the world, took up investigations bearing on these questions. As would naturally be expected, these early investigations were restricted to experiments in laboratories, greenhouses and gardens. In Europe, something has been done in experiments with field crops and orchards, but in this country no reports of extensive field trials have heretofore been made.

In October, 1913, I arranged with the Standard Chemical Company of Pittsburgh, Pa., to make preliminary trials on an extensive scale. In view of the cost of radium and its preparations, the reader may wonder how such an experiment could be undertaken. It requires about 400 tons of radium ore of standard quality to yield a gramme, about 15½ grains, of radium, which amount could easily be carried on a man's thumb nail. The regular market price is $10,000 a grain, or $120,000 a gramme, equal to $70,000,000 a pound. This problem was solved by making use of the finely powdered residue remaining after all the radium possible has been extracted, but leaving some two or three milligrammes to the ton, worth some $3,000, yet a by-product unless a special use for it could be discovered. Various other substances, especially uranium, are present in the material.

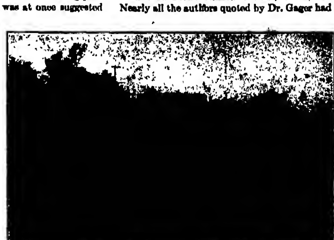
Before proceeding to describe these experiments and their results, it is desirable to briefly summarize the results of previous experimental work.

The most extensive work that has been published in English of the influence of radium on the growth of plants is that of Dr. Charles Stuart Gager, of Brooklyn, N. Y., which appeared in the fourth volume of the "Memoirs of the New York Botanical Garden," December 2d, 1908. Nearly all the authors quoted by Dr. Gager had reported

* From a lecture delivered at the New York Botanical Garden on November 14th, 1914, and published in the *Journal* of the Botanical Garden.

[1] Strictly speaking, the term "emanations" applies only to the residue left after the first rays (alpha rays) have separated from the radium atoms.

Globe turnips, two hundred pound plot at left, one hundred pound plot at right. Late celery in rear.



Celery at left stunted by excess of R. A. F.; left side of adjoining plot affected by emanations crossing path.

Celery in foreground; next, four plots of turnips, at right without R. A. F., but its left-hand portion favorably affected by emanations crossing path from twenty-five pound plot.

that the effect of radium was to retard or inhibit plant development, results which, as it will be here shown, were due to the use of enormously excessive quantities. Guilleminot had especially commented on the difference between the effects of low and high activities. He stated that while a certain low activity had no effect upon plants, the effect of from six to twelve times that amount would markedly retard growth, and from eighteen to seventy-two times would completely destroy. Yet he expressed the opinion that there was no strength that would positively stimulate growth. It was said that the distance at which the radium would act was limited to about 2 centimeters, less than an inch. Roots were found to be more susceptible than other parts of the plant. Some plants were more resistant than others and the turnip was mentioned as being especially so. Excessive branching of certain tissues was reported. It was found that parts of plants exposed to radium emanations would themselves become radio-active. The degrees of such radio-activity were, the root most, then, in order, stems, buds, leaves and flowers. It was decided that this activity did not exist in the tissues themselves but in their contained water.

Gager himself employed numerous methods of experimentation. He used tubes of glass and other substances which were coated on the inside with substances containing radium. He also used rods similarly coated on the outside. Such tubes or rods would be laid upon dry seeds for various periods of time and the seeds were then planted and their germination and growth compared with those of others not so treated. Seeds were soaked in water containing the emanations and were then planted and similarly compared. Plants were grown in water containing the emanations, while others, growing in the soil, were watered with such water. Plants were grown under bell jars in air that was kept charged with the emanations. Radium tubes and rods were buried in the soil in which seeds were planted. The radio-activities to which the seeds and plants were subjected in these experiments varied from 7,000 X up to 1,500,000 X, all of which, however, we now know were excessive. He always found the damage greater with the increase of activity. Similarly, he found that the seeds farthest away from the buried tube showed successively less injury. In short, it is seen that in every case of a change of conditions which resulted in a lower activity being exerted upon the seed or plant, the damage was less and he did not fail, as Guilleminot had done, to find strengths that would markedly stimulate germination and growth. He finally reached a conclusion expressed as follows: "*The rays of radium act as a stimulus to protoplasm. Retardation of growth following exposure to the rays is an expression of over-stimulation: acceleration of growth indicates stimulation between a minimum and an optimum point.*" He agreed that the root was more affected than the other parts of the plant, and his experiments show that members of the grass or grain family are more strongly influenced than others with which he experimented. He concluded that the gamma rays can penetrate as much as a foot in moist soil. As my own experiments show, they produce important effects at a distance of at least seven or eight times as great as this.

In France, Petit and Ancelin reported that by placing the seeds between sheets of blotting paper moistened with radio-active water, not only were a much larger number of ray-grass seeds germinated than when plain water was used, but the roots at the end of the thirteenth day were ten times as long as in the latter. With wheat and corn the increased length was not so great, but was very marked, as was also the greater length of the stems.

The National Agricultural School at Grignon, France, experimented with six varieties of potatoes and obtained by the use of radium an average gain of more than 16 per cent in the weight of the crop, the potatoes at the same time containing more starch and being correspondingly more mealy and palatable. Barley so treated gave 17.6 per cent more straw and 12.5 per cent more grain. Mustard gave 27 per cent more straw and 34 per cent more seed. Flax gave 24 per cent more straw and 6 per cent more seed. White vetch gave 10 per cent and fenugreek 11.5 per cent more fodder.

At the Agricultural School of Berthonval, the experiments were made on plots of a hectare each. Upward of a 15 per cent increase in the yield of grain was obtained by the radium treatment and over 14 per cent in that of sugar beets.

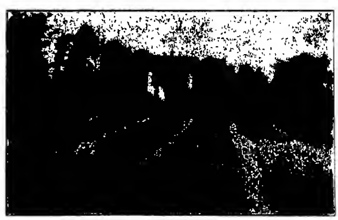
At the Harper-Adams Agricultural College at Newport, Foulkes also obtained a 14 per cent increase in the yield of table beets and more than 20 per cent in turnips, plots of a hectare each being employed.

Messrs. Vilmorin, Andrieux & Co. and others experimented with flowers, obtaining very satisfactory results on chrysanthemums, roses and other cut flowers.

All experimenters with plants in pots have reported such phenomenal increases in root development that the plants quickly became root-bound and had to be successively

Southern half of northern half of farm, looking west from neighboring roof.

The DD plot of cabbage (treated with twenty-five pounds of R. A. T.). It will be noticed that many leaves have been destroyed by cutworms.



Effects of R. A. F. on onions (lightly shaded plots). The two hundred pound plot is at left, the control plot is at right and scarcely showing.

transferred to other pots of a considerably larger size.

A most extensive series of experiments has been carried on at Joachimsthal by Dr. Julius Stoklasa, director of the Chem.-Phys. Institute at Prague. These experiments extended over a period of 7 years, the results being embodied in a voluminous report, made in September, 1913. There were many series of experiments. In one set, the plants were grown in ordinary soil and watered with water possessing various degrees of radio-activity. In another set they were grown in water supplied with plant food similarly charged, while in another set radio-active earth was employed. The following results were obtained:

The first experiments were directed toward ascertaining the effects of radium upon the activity of those bacteria which take nitrogen from the atmosphere and fix it in the soil in the form of plant food, thus enriching the soil. He found that liquids containing these bacteria gained from 32 per cent to 76 per cent more plant food in this way under radio-active influence than without it. Unused soil gained from 10 per cent to 30 per cent more fertility in a few months from this cause under the same conditions than without the radium.

Many previous experimenters had reported that radium exerted a toxic action on plant life, while others had declared to the contrary. Stoklasa repeated all these experiments, but in two series, one with very small amounts, the other with large amounts of the radium. He found that in most of the latter cases the effects were toxic, while in the former they were healthfully stimulating. He also found that different plants differed so materially in their susceptibility that the same amount of radium might be stimulant to one but toxic to another. What was even more interesting and important, he showed that families of plants manifested this difference.

When a very low radium activity was employed, the germination of seeds was increased from 70 per cent to 130 per cent, but it was retarded by a high activity. Drying and weighing two sets of plants after 48 days of growth, one set grown under radio-activity, the other not, the former showed an increase of over 200 per cent in peas, over 100 per cent in beans and lupines and nearly 900 per cent in barley. In another set of experiments, with lentils, peas and wheat, the gain by the use of radium ranged from 62 per cent to 158 per cent. With buckwheat, the increase ran from 42 per cent to 100 per cent. With poppies, there was an increase of 117 per cent in the seed, and 32 per cent in the plant exclusive of the seed, or 50 per cent in total. With lupines the seeds gained 64 per cent, the total gain being 60 per cent. The greatest gain was in the early stages of growth, the ratio decreasing thereafter.

These studies taught that all the main functions of the living cell are greatly stimulated by radium. The fact that starch production went on in darkness, and other corroborative facts, indicated that the effects of the radium closely resembled those of the ultra-violet rays of the sun.

Stoklasa also succeeded in synthetizing sugar by this radio-activity. The bearing of this fact upon the possible increase in sugar production by plants is momentous. It also explains the great increase in sweetness observed from the radium treatment of beets, carrots, tomatoes, pumpkins, squashes, melons, sweet corn and other vegetables. The fact that sugar-beets showed no increase in sugar content is perhaps due to their having reached a practical maximum in sugar production.

He summarizes as follows:

"All of our researches point to the fact that radium emanations with a low activity favorably influence the caryokinesis of the cell, the entire development of the plant, the mechanism of the metabolism, the photochemical assimilation in the chlorenchyma, bud formation and finally frutification. Emanations of too great activity exert an inhibiting influence on the growth of the plant and cause toxic symptoms in the cells, both in those containing chlorophyll and those without."

He also says that if we assume under ordinary conditions land will produce 200 hundredweights per hectare of corn or cattle turnips, we may expect 300 or 400 hundredweights under the influence of radium.

He concludes, finally, that the effects of radio-activity are greatest on young foliage and almost equally great on the petal tissues of the flower.

Against this array of positive evidence as to the stimulating effects of the radium, I had the negative effect of a caution from the French Agricultural Bureau against the probability of such a pronounced action as had been reported, on the ground that the amounts of radium in radio-active earths which had been employed were so very small. Little weight could be given to this suggestion, because of its purely speculative character. Although it was pointed out that ordinary farm soil is radio-active, often more strongly so than the radium mixture that was applied in the experiments, it was a pure assumption that this activity is wholly due to radium, or that such radium is actually present in the top-soil, and in fact it seems far more probable that it is in part due to the direct effect of the sun upon the soil. However, the case was one that called pre-eminently for the actual test of experimentation and to this I applied myself in the most practical possible way.

I made it my business for the time being, to ignore all theoretical considerations and to proceed with my trials precisely as a farmer would proceed in preparing the land and applying the radio-active material for a market crop.

My experiments and observations included the winter culture of radishes in a market gardener's greenhouse, some seedlings in window boxes in my own home; field crops covering more than 100 acres at Northfield, Ohio; under the direction of Mr. W. W. Darley, an experimental gardener at Pittsburgh, and the plantation of an acre and a half at Nutley, N. J., of which I have had immediate personal charge throughout the season.

The greenhouse radishes were already about an inch high when the radium was applied. A furrow was scratched midway between the rows, which were 4 inches apart, and the powder sowed therein at the rate of 16 grains to the square foot, which is equal to about 80 pounds to the acre. A square yard was thus treated and was compared with an exactly similar square yard upon the same bench, about 10 feet distant. The radium radishes soon appeared much inferior to the others, and continued to do so to the end of the experiment, the tops being smaller, as though stunted, but on harvesting and weighing the green tops and the roots separately, the tops were found to weigh 17 per cent less from the radium plot than from the other, while the radishes weighed about 20 per cent more.

The season of growth had been very bad, February being very stormy, with little sunshine, and that little largely excluded by snow lying upon the glass roof. This observation is of much importance, indicating that it required less green leaf surface under deficient sunlight for the plant to manufacture a larger amount of food for deposit in its root. It will later be seen that various other experiments indicate and elucidate this principle.

Both of my window boxes were filled from the same pile of soil, similarly treated in every way except that in one the above-mentioned amount of radium earth was mixed through the soil. All operations were conducted for both boxes at the same time. Their positions in the window were exchanged from time to time, so as to preserve absolute equality of conditions. In the boxes I sowed cabbage and tomato seed in alternate rows. The seeds germinated one or two days earlier in the radium box and the plants were already well developed when those in the other box broke through the ground. The difference was more marked with the cabbages than with the tomatoes. The original lead of the radium plants continued to increase throughout the experiment, and after some two months, when the experiment was brought to a close, a given number of plants in the radium box would have weighed from six to ten times as much as from the other.

In Mr. Flannery's garden I particularly noted the great gain of turnips and beets under the radium influence over those without it. Radishes, which I did not myself see, were said to have yielded more than 100 per cent increase under the radium treatment. The quality of the radium-grown vegetables was a matter of special comment by all who tried them, and this has proved true of all vegetables raised elsewhere under this treatment.

(To be continued.)

Fuel Oil in the Navy

The following interesting facts are given in relation to the use of fuel oil in the United States Navy in the report on the production of petroleum in 1913 issued by the U. S. Geological Survey:

Tests have been carried out during the year at the fuel oil testing plant at Philadelphia with a view to making the naval specifications for fuel oil less strict in order to get an oil at a cheaper price.

During 1913 a board was constituted in the Navy Department to determine a proper flash point for fuel oils to be used on battleships. The importance of this subject has been recognized by reports from various experts to foreign governments, which have resulted in the adoption of the following minimum flash points for fuel oils for naval purposes:

Minimum flash points adopted for fuel oils for naval use.

	Deg. Fahr.
United States	*150
Great Britain	175
Germany	187
France	200
Russia	212
Italy	212
Austria	248

The board began its investigation by adopting the following assumptions:

(a) That oils having viscosities such that they must be heated in the bunkers must have such a flash point that no explosive or inflammable mixtures are formed therein.

(b) That it is undesirable and dangerous that oil should be heated anywhere—in bunkers or in firerooms—above the point where explosive or inflammable gases are given off.

(c) That the reliability of the flash cup in determining the point at which this condition of explosive mixture begins to exist should be checked in order that a guide may be established which may be known to be safe and positive.

*Reduced from 175 degrees by recommendation of this board.

The board then obtained large samples of oils which showed characteristics given in the accompanying table. These oils include the characteristics of practically all known fuel oils.

The first problem investigated by the board was to find the temperature at which various oils must be heated in the bunkers in order that the pumps may take more than the quantity for full-speed steaming conditions. With pumps such as used on battleships three grades of Mexican oils were used, those designated as 15.4 degrees, 17.3 degrees, and 11.7 degrees gravity Baumé, the last representing the extreme of viscous oils on the market. The suction was taken from the 1,200-gallon submerged oil tanks with about an 8-foot lift from about 100 feet of 3-inch piping bushed down to 2½ inches at the pump. The following results were obtained:

Pumping capacity of pumps for different oils at varying temperatures.

Temperature (deg. Fahr.)	Toltec, Mexican, 12 deg. Baumé, gallons per hour.	Mexican, 15.4 deg. Baumé, gallons per hour.	Mexican, 17.3 deg. Baumé, gallons per hour.
65	87	....	417
72	120	296	....
75	130	376	1,105
80	173	717	1,414
90	295	1,365	1,907
100	488	1,904	2,346
110	683	2,486	2,970
120	987	3,000	3,348
130	1,360	3,516	3,696
140	1,775	....	....
150	....	4,190	4,063

The board estimated that the standard Blake pump used in this test, which conforms with the installation on board ship, requires that this pump should deliver 564 gallons an hour, in order to secure an adequate quantity for full power. This, then, is taken as the standard of comparison in determining the temperature to which oil must be heated in order that the suction pumps may supply an adequate quantity for full speed.

It will be seen that the 17.3 degrees Mexican oil must have a temperature of 67 deg. Fahr. or above in order that the pump may take an adequate supply for full speed; the Mexican 15.4 degrees, a temperature of 77 deg. Fahr. or above; and the Toltec (Mexican) 12 deg. Baumé must be heated to 105 deg. Fahr. This latter result is considered by the board as the limiting temperature. The board ascertained that it is the practice on the Southern Pacific steamers burning this oil to heat up to 115 deg. or 120 deg. Fahr.

The next problem was to sample and analyze and attempt to ignite the gases given off in the bunkers at these temperatures, in order to ascertain the danger of such heating of oil in the bunkers. The investigation showed that no inflammable gas is formed under conditions similar to those in the bunkers of ships until the oil is heated to its flash point, and that the Abel Pensky-Martin closed flash cup gives results which check with the results obtained in the tank. The experiment showed that the fuel oils in this experiment did not contain dissolved gas or vapor sufficient to form any explosive mixture until a temperature equivalent to flash point was reached. Examination of the air over the fuel oils in the bunkers of various battleships showed that this air did not contain more than an insignificant quantity of combustible vapor. Almost 0.9 per cent of combustible vapor must be present in a mixture of vapor and air to form an explosive mixture. The largest amount found was 0.04 per cent. The following conclusions were reached:

1. At the flash temperatures the vapors produced constitute about 1.0 to 1.25 per cent of the mixture of air and vapor. They consist principally of vapors of the liquid paraffins, hexane, and heptane.

2. On board ship these oils can be heated to within about 15 deg. Cent. (59 deg. Fahr.), of their flash point before even a noticeable halo or partial burning occurs should they be accidentally inflamed.

3. The flash points shown herein are a good indication of the temperatures to which the oils can be heated before an explosion of the released vapors can occur.

Effect of Climate on Location of Manufacturing Plants*

An Important Factor That Often Determines Economic Success

By William M. Booth

Before discussing the location of a plant, let us divide manufacturing industries into groups respecting the source of raw materials or their equivalent.

1. Those that are compelled to locate near the source of the raw material, such as lumber mills, flour mills, cotton gins, sugar cane mills, beet sugar factories, cement plants, quarries, cheese, butter and condensed milk factories, canning factories and meat packing houses.

2. Those that must locate at or near a natural source of power, such as plants producing electricity from water power.

3. Plants, the location of which is fixed by fuel supply; coke production, steel and iron furnaces.

4. Good market locations; foundries and machine shops, clothing manufacturing, all articles of household use, water and gas plants.

5. Plants, the location of which is determined by climate; cotton and silk carding and spinning, and linen weaving.

6. Industries, the sites of which should be chosen; as agricultural implements, automobiles, cotton and woolen manufacturing, boots and shoes, brass products, smelting and refining, carriage and wagon factories, chemical manufacturing, knit goods, leather and paint plants.

For the latter, No. 6, fuel and raw materials may be shipped hundreds of miles if the related conditions are favorable. A careful analysis of the factors of location should be made for this class.

The shipment of fuel, stock and finished products places the manufacturer at the mercy of the transportation companies. Our northern climate absolutely prevents the continuous use of inland water ways for from three to eight months annually. To avail himself of cheap water freight rates, the manufacturer must move a year's supply of fuel or stock during the short navigation season. What is gained in a low rate is often more than outbalanced by interest charges on materials which must be protected by insurance in a warehouse. The railroad more nearly approximates a perfect system of transportation. This, however, is also subject to the vagaries of climate throughout our main manufacturing belt.

All classes of manufacturing in central and northern New York suffer annually from lack of fuel supply during January and February. Stalling of raw stock and frequent passenger and freight demoralization north of a line connecting Portsmouth, N. H., Pittsfield, Mass., Troy, N. Y., passing through Utica, Rochester, Buffalo, Detroit and Milwaukee, is not uncommon. In this region, shipments are lost in snow drifts and passenger service is sometimes suspended.

All power plants suffer from low temperatures. Water ways accumulate anchor ice that is difficult to handle and frozen water mains cause hours of delay and require many dollars to repair. Water, steam and soil pipes are necessary in every industry. The further north the location, the greater the annoyance and expense incident to frost.

Being no respecter of persons or things, gas is not exempt from the ravages of cold weather. In a northern city, a main of considerable size was carried over a bridge through a boxed conduit packed with horse dung. During a spell of extremely cold weather, I found the candle power of the gas lowered from 14 to 9 at this crossing.

I do not know of an instance where the extreme heat of our northern summer has any marked effect upon the mechanical equipment of railroads or the power plants of mills. Labor, however, responds quickly to climatic changes. During July and August, the cities in our manufacturing belt are subject to about three weeks of what is termed "close" "hot" weather. Many plants give employees an enforced vacation and take advantage of this time for the annual "clean up" and the necessary repairs. When the temperature reaches 80 deg. Fahr. in Central New York with extreme humidity, the average workman is incapable of much effort, either physical or mental. The mercury sometimes steadily climbs by [illegible] day until it reaches the 100 degree mark. Factory discipline is demoralized, all are nervous, irritable and cross. Production suffers accordingly, unless there are many automatic machines. Men in foundries, before furnaces and ovens and in closed areas, or [illegible] special apparatus accustom themselves to great [illegible] accordingly.

[illegible] are sometimes low, compared with the surrounding country. Extended areas of this character are often covered by fog from 4 until 8 o'clock A. M. during periods of high humidity and cool nights. Summer colds become epidemic from damp rooms and air.

Severe snow or rain storms are shown on the time clock records by tardiness and absence. Such may occur when orders are abundant and help is scarce or when a special order must be finished by a certain time. Severe and inclement weather over a period of several days sometimes demoralizes a northern mill where women are employed. Uniformly bad weather compels operatives to live but a short distance from the plant, which is usually a disadvantage from a home standpoint.

Considering extremes of heat and cold, white labor seems best qualified by temperament to work in the isothermal belt bounded by the 45th and 50th deg. Fahr. lines. Intensive miscellaneous manufacturing cannot thrive in the areas south of this because white help cannot work the year around in closed rooms at the high temperatures found south of Baltimore. The indifference of labor in the so-called "black belt" of the extreme south is one of the greatest handicaps to the manufacturer who builds a plant where extremely cheap labor abounds. Besides picking cotton in the open, the colored man has little value in the skilled labor market.

I see no reason why intensive manufacturing cannot be carried on in Washington State and Oregon, as soon as labor and market conditions warrant such activities. The humidity is sufficiently high in Portland and Seattle for textile mills. White employees can be utilized, for the 45-50 deg. Fahr. isothermal of the east also includes these localities. California must depend very largely in this particular upon Asiatic races now employed in the fields, -Hindoos, Chinamen, Japanese and Malays.

Parts of Texas, Arkansas, Colorado and Utah are sufficiently elevated to attract white labor in mills during the greater portion of the year.

Atlanta has such an elevation as to place it in a temperature class considerably further north—about 3 deg. Fahr. In the east, all locations are greatly favored by a medium altitude. There are many mining camps in the United States, however, the elevation of which is sufficiently great to seriously affect the workmen. Those with weak hearts cannot be employed and the extreme dryness of the air cracks the lips, face and hands. The body tires easily and a heavy day's work is absolutely out of the question. At some altitudes, women cannot be employed, due to their sex.

It may seem unnecessary to mention the effect of sunshine upon labor. This is, however, an important consideration as the mind is more free and the body alert during a bright day than on a dark or cloudy one.

Machinery is ordinarily free from atmospheric changes. However, warm weather loosens belts and lowers the percentage of product. I have timed a machine, turning out 8,000 pieces per hour, and have found a difference of 600 pieces, due to irregular belt slipping.

We now come to the most important feature of our subject to the manufacturing chemist. I refer to apparatus and process work. My attention was first called to this in testing out a milk drying machine at an altitude of 1,100 feet. Neither thermometer nor barometer satisfied the conditions imposed. We finally settled the difficulty by reducing directions to changed altitude and succeeded fairly well.

In the manufacture of gelatine capsules, small cone-shaped forms are dipped into liquid gelatine. These pass out of the fluid, are elevated and dried by a current of warm air. This must be dry, and should be kept uniformly so by a conditioning process. One of the most hygroscopic substances with which I am acquainted is glucose. This has many uses and will absorb enough water to spoil other bodies with which it is mixed if the air is humid; equally difficult to manage is dry malt. Flour must be barreled and starch must be boxed in a dry room. Glycerine is very hygroscopic. Calcium chloride and caustic soda should be handled in very cold or dry air. Chloride of gold cannot be bottled on very moist days. Dry laundry chemical mixtures should be mixed and bottled or boxed in a dry atmosphere to prevent caking.

On the other hand, linen, cotton, jute and hemp must be spun and woven in very moist air. Many thousands of dollars have been lost by erecting a textile plant in a locality where the air is too dry. Fall River, Providence, Lawrence and Lowell owe their being to a moist (75 per cent humidity) air, with fairly uniform temperature, favorable to cotton spinning. Cotton manufacture has failed in dry air localities; it flourishes in moist air. The city of Denver was chosen for cotton mills and the experiment tried but partially failed because of lack of moisture. Small steel metal parts must be made in a reasonably dry climate. The enameled leather business is dependent upon sunshine. I have known a plant practically closed, waiting for a sunshiny day, that the leather might be banked in the open air, facing the sun.

When a superintendent tells me that climate has no effect on his output, I know he has not made a study of his conditions. I have never yet been in a mill where climate does not exact a penalty due to the carelessness or ignorance of the management. The finished product is no exception to the exactions of temperature. Food products and aqueous solutions must not freeze; japanned articles must not be chilled; metal parts must not be packed in damp material or stand in damp places in transit.

Northern mill owners and workmen are subject to a climate tax in the way of fuel, which may be estimated. In central New York, an industry employing 200 men and women burns three tons of coal for heating purposes exclusively, during each 24 hours of the winter months. This coal costs \$3.00 per ton. Exhaust steam is not available as it is used for other purposes. The 200 employees represent about 60 families that burn on the average six tons of coal each annually for purely heating purposes. This costs \$6.00 per ton; a total of about \$4,000 for fuel due to a northern location in what may be considered a small industrial center in a country village!

To attempt to locate an industry where destructive wind storms are unknown would be impossible.

The annual floods of the Ohio and Mississippi valleys cause hundreds of thousands of dollars loss. Of this manufacturers pay their share.

The Allegheny mountains system contains many narrow valleys with steep sides that have been appropriated by manufacturers. Great loss occurs through the freshet season.

Syracuse users of Niagara electric current have occasionally been greatly inconvenienced by loss of power and light when feed wires are struck by lightning somewhere along the line. I understand that this difficulty is not uncommon where electric power is utilized and conveyed great distances at high voltage.

I have had two objects in view in the preparation and presentation of this paper. The first of these has been to unite certain data that have been collected by the weather bureau for various purposes and to apply these facts to the solution of the problems of plant location.

Having plotted an area that satisfies climatic conditions most favorably, this becomes one unit of a system of maps that may be superimposed, each of these representing the best location for an industry and covering the following:

Accessibility of raw materials, market, transportation, labor, power, water, supplies, climate, hygienic conditions, taxes, insurance, banking facilities, heating and lighting.

A practical manufacturing site can, for a given industry, be determined in this way in advance of the purchase of property or the erection of buildings.

The second object of this paper is to show that owners, superintendents and operators of manufacturing plants have seldom considered the various favorable and unfavorable effects of climatic change on the business in their charge, that many improvements may be made even in poor locations by heating, cooling, drying, filtering or adding moisture to the air of their rooms where operators work or where delicate processes are carried on.

*Abstract from a paper read by Wm. M. Booth before the Am. Institute of Chemical Engineers, and published in the Proceedings of [illegible].

A Handy Foundry Cupola

At the Puget Sound Navy Yard, where the work did not warrant the regular operation of their foundry, there were frequent demands for a few small castings for quick delivery, and to make these by the regular foundry cupola of 6,000 pounds capacity entailed great waste and expense. To meet the difficulty a little cupola of 600 pounds capacity was constructed out of discarded material picked up around the shops which has done excellent work and proved very satisfactory. It is only about 4 feet high from the base, and the internal diameter inside the lining is 14 inches. The tuyeres, two in number, are rectangular in shape, and expanding, with their lower edges 10 inches from the bottom. The opening is 6½ inches wide at the broad end and about 5 inches at the narrow end by 4 inches deep. The ratio of cupola area to tuyere area is approximately three to one. The bottom plate is a casting incorporating the spout; the cylinder is made of steel plate. The blast is taken from the compressed air system of the yard. It induces air in a three-stage injector and delivers it to the cupola about fifteen times its own volume.

Photographing Projectiles—II*

By Means of Illumination from Electric Sparks

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2047, Page 205, March 27th, 1915

Fig. 15 is an old Mauser bullet in flight. The impressions of the rifling are plainly visible in the lead bands. The point of discharge of the electric spark is behind the projectile.

Fig. 16 represents the same bullet; the point of discharge of the spark is at the lower side of the bullet. Upon the head of the bullet straight lines were drawn and numbered. From the sharpness of definition of these marks in the photograph, it is to be inferred that it is feasible, by taking two photographs of the same bullet, at the beginning and at the end of a measured distance, and employing a method for discharging the sparks not readily disturbed by the motion of the projectile, to measure the number of turns with very satisfactory accuracy.

Fig. 17 is the infantry bullet in flight at a distance of about 2 meters from the muzzle. The impressions of the rifling are plainly visible in the negative. We are thus in a position to ascertain whether the projectile follows the rifling or not. The picture shows, besides the bullet in flight, one of similar characteristics at rest. Comparing the length of the bullet in flight with that of the one at rest, we are in a position, the velocity of the bullet and its true length being known, to determine the length of time required for making the image on the plate in lighting by means of the electric spark, or at least to obtain a superior limit for the lighting interval. This determination naturally applies only to the special conditions under which the photograph was made; that is to say, for a spark light of definite capacity and length of spark diffusely reflected and passing through a lens. Two separate determinations gave the following values: for a capacity of 45,000 the lighting interval was 0.4 millionth of a second; for a capacity of 3,500 and another projectile the lighting interval was from 0.19 to 0.13 millionth of a second. For the latter figure the details were as follows: lengthening of the picture, determined by a projection apparatus and Zeis scale, 16.1−16.0=0.10 centimeter; photographic reduction, 1.735 to 1; that is to say, the apparent lengthening of the projectile is to be multiplied by 1.735 millimeter to determine its true value. The velocity of flight is 890 meter-seconds; and the lighting interval is $\frac{0.1735}{1000 \times 890} = 0.19$ millionth of a second; by measuring the same negative with a microscope the interval is found to be 0.13 millionth of a second.

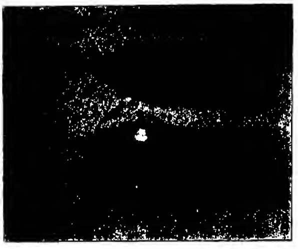


Fig. 15.

Fig. 17.

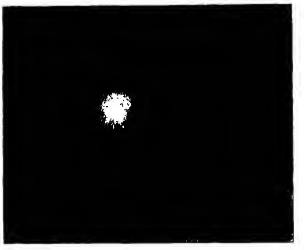


Fig. 16.

Fig. 18 shows the dial of a Hipp's clock, with two exposures on the same negative, while the clock was going. The first illumination was effected by means of a projectile of Model 88, completing, in its flight, an electric circuit by connecting two sheets of tinfoil near the muzzle of the gun; and the second illumination occurred when the same projectile after a further travel of 45.48 meters connected two other sheets of tin-foil. The time of flight of the Model 88 bullet and the mean velocity may now be determined as follows: The long hand has passed across the graduation mark numbered 45. One edge of the small hand has in the same time advanced from 79.6 through the zero to the position 52.6 (the readings should be obtained by enlarging the negative with a projecting apparatus, when the figures after the decimal point cannot be in error more than a single unit). The two readings of the clock are then 4479.6 and 4552.6, and the time of flight is 4.5526 − 4.4796=0.0730 second, according to Hipp's clock. The test of the Hipp's clock

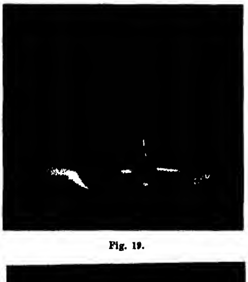


Fig. 19.

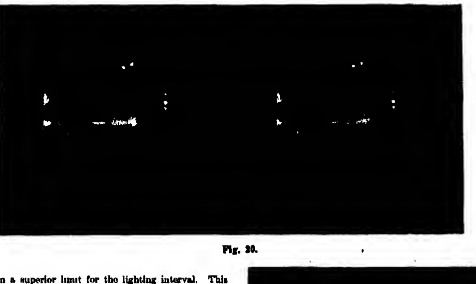


Fig. 20.

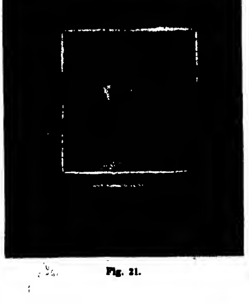


Fig. 21.

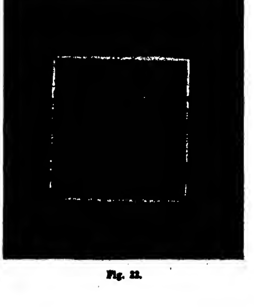


Fig. 22.

* By O. Crans, P. A. Günther, Captain, 49 th Regiment, Field Artillery, and F. Kulp, Captain, 118th Regiment Infantry. Translated from the *Zeitschrift für das Gesamte Schiess-und Sprengstoffwesen* for the *Journal of the United States Artillery* by Charles A. Junken.

Fig. 23.

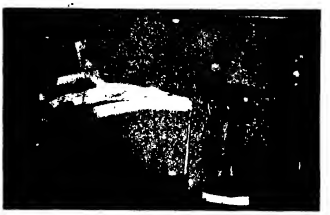


Fig. 24.

by means of an ordinary clock showed that 20 seconds true time was 20.085 seconds by the Hipp's clock. The time of flight of the projectile in true time is, therefore, $0.073 \times \frac{20}{20.085} = 0.727$ second. The measured travel being 45.58 meters, the mean velocity is $45.58 + 0.0727 = V_m = 627.0$ meter-seconds. According to A. Burgsdorff

Fig. 18.

the mean velocity of the bullet Model 88, is $V_r = 640$ meter-seconds; while the mean velocity of the same bullet determined at an earlier date in the Ballistic Laboratory was $V_m = 624.7$ to 627.0 meter-seconds. We may therefore conclude that the deduced value, $V_m = 627.0$ meter-seconds, is thoroughly established for this individual bullet by the several methods of determination. But it is far from our intention to substitute for the established practice a new method of measuring the velocities of projectiles; it is better to restrict the method to laboratory use exclusively.

Fig. 19 shows the bursting effect of the S-bullet in perforating a freely suspended rubber bulb filled with water. The bullet has perforated the rubber bulb and is passing out of the field of view to the left. The rubber covering has been sharply distended in the direction of the projectile, and will subsequently be torn completely apart, the water being thrown in all directions. (The object of this and similar photographs is a reply to such questions as those asked us by the celebrated army surgeon Doctor von Bruns in regard to the ways and means by which the head of a bullet is deformed in perforating soft parts of the human body.)

Fig. 20 is a stereoscopic photograph of the same.

Figs. 21 and 22 show the explosive effect of the S-bullet on moist clay. Within a wooden box (Fig. 21) a ball of moist clay is placed in the line of fire; close behind the clay ball are the points of discharge of the electric sparks; the four illuminating spark-plugs are connected by short conductors with the condensers and discharged one after the other; they are visible at the four corners of the box. In Fig. 22 is shown the same clay ball as it appears shattered after perforation by the S-bullet, fragments being scattered in all directions, but remaining constant in volume. These fragments were thrown with great force against the walls of the box toward the gun and to the rear.

Fig. 23 is a stereoscopic photograph of a ricochet on the water.

Fig. 24 is a fan in rapid revolution. During the incredibly short period of illumination the fan appears stationary. That it is actually revolving is shown by its effect on the paper strips.

Fig. 25 shows falling drops of water. The phenomena well known to natural science concerning the separation into single drops of the steady stream and the periodical formation of the falling drops are actually reproduced in this photograph in an unusually clear way.

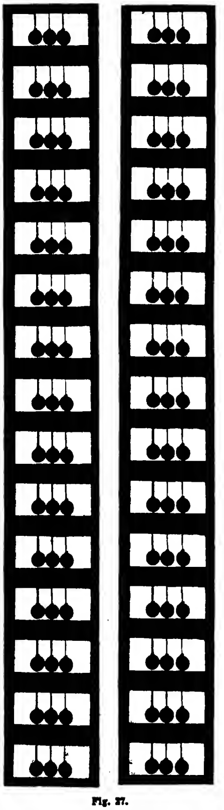


Fig. 27.

Fig. 26 shows the same phenomena for quicksilver from a small opening, under slight pressure.

Fig. 27 is moving-picture film made with a time interval of 1/5,000 of a second from picture to picture.

In order to illustrate the characteristic difference between kinetoscopic shadow pictures and kinetoscopic photographs lighted from the front, there is given in

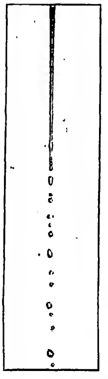


Fig. 25.

Fig. 26.

Fig. 27 a section of a moving picture film made with light from the background, that is to say a series of shadow photographs. Two steel balls are so suspended that when they are at rest they lie close together. A third ball swings from the left and strikes against the first ball at rest. After the blow, the first, or middle, ball remains at rest, even after the full stroke; the second ball formerly at rest swings off to the right. The whole film, which consists of 300 pictures, was obtained with concave mirror and objective by Mach's characteristic methods. One picture follows the other at the rate of 1/2,500 second. Such serial shadow pictures are comparatively easy to obtain with the ballistic kinetoscope of the laboratory where is obtainable sufficient light, shining directly from the rear, past the balls, and falling on the objective lens of the camera. It is vastly more difficult, however, to obtain such serial negatives with the ballistic kinetoscopic methods in common use, employing frontal illumination; that is, using the light reflected into the object lens of the camera from the face of the object to be photographed. It is practicable to obtain such pictures of a moving object at all only by intensely concentrating the electric spark light.

The Harmful Constituents of Roasted Coffee (Coffee-Toxin)

The disturbances of the digestion which follow excessive coffee drinking are considered by the author, in a communication to the Société de Therapeutique, not to be due in any degree to the caffeine, but solely to certain volatile constituents formed, and only partly volatilized, during roasting. These are named cafeotoxin, and may be eliminated by submitting the roasted coffee to successive treatment with steam under pressure of several atmospheres, following by exposure under a vacuum. The coffee thus treated is called "atoxicafe." It retains its caffeine unaltered. It differs from ordinary coffee only in containing less cafeotoxin. Cafeotoxin has a marked reducing action on haemoglobin, a hypotensive action on the circulation, a depressant action on the central nervous system, occasioning cardiac arhythmia, and on the respiratory centers, causing dyspnoea.—*Pacific Phar.*

The New Knowledge of Coal Tar*

Scientific Methods for Utilizing the Products of Coal

By Horace C. Porter

THE INDUSTRIAL IMPORTANCE OF COAL.

THE question may be asked: Why should a chemical-engineering course begin with a lecture on coal? Is the efficient use of coal a fundamental thing in engineering?

Unquestionably power production stands as one of the foundation stones in the structure of any industry, and of the total power which operates modern industries at least 80 per cent is derived from the combustion of fuel, a chemical process. Coal and coke and gas made from it constitute 85 per cent of the industrial fuel of America.

Proportionate cost of power varies widely in the different industries, but taking them as a whole, census reports show that fuel constitutes about 8 per cent of the operating costs (exclusive of the cost of materials) in manufacturing industries. The importance of efficiency in the use of fuel becomes at once apparent. Over 150,000,000 tons of coal are used for industrial power. If the percentage utilization of the energy of this coal were everywhere increased by 8 per cent, an increase entirely possible through the use of modern, improved, steam engineering appliances and of the gas producer and gas engine, the cost of the industrial fuel used in the United States would be cut in two, and at least $150,000,000 saved. If all the coke produced in the United States in 1913 had been made in by-product ovens, $80,000,000 worth of by-products might have been saved and $10,000,000 in higher yield of coke.

Coal is by far the biggest mineral product of the United States. The production in 1913 was about 570,000,000 tons and the bulk of this was consumed in our own land. The nation's coal bill was, therefore, in the neighborhood of 1½ billions of dollars, or $40 for each wage-earner per annum. The United States is far ahead of other nations in coal production, having passed Great Britain, the nearest competitor, in 1899, and now surpassing her by nearly 100 per cent. Since we export very little coal and other nations export a great deal, our home consumption surpasses that of other countries by even a much greater margin. Our industries are greater, to be sure, but we must face the fact also that an abundance of fuel resources has made us careless of efficiency in their use.

The coal reserves of this country are immense, the most recent estimates of the United States Geological Survey (for the XII International Congress of Geology, Canada, 1913) showing 1,500 billions of tons easily available, not including the sub-bituminous and lignitic coals, these being not widely used now. If production should increase in the future at the rate it has in recent years, the exhaustion of our high-grade reserves may come at no very distant day. But unquestionably there will be a tendency toward a lesser rate of increase in consumption as the present movement toward greater efficiency in the mining and use of coal gains headway and brings results.

We may inquire somewhat analytically: What are the uses of coal and in what way can they be made more efficient? The 570,000,000 tons produced in 1913 in the United States were used approximately as follows:

	Tons.
Domestic	120,000,000
Other heating of buildings	85,000,000
Coke and gas	75,000,000
Locomotives and steamboats	110,000,000
Industrial power (including central power plants)	180,000,000

Scientifically the methods of utilizing coal may be classified into (1) combustion, (2) carbonization, and (3) gasification by partial combustion. Probably 80 per cent of the coal consumption in America comes under class (1), i. e., it is burned in air directly, and we see therefore, the great importance of improving practical methods and appliances for combustion.

COMBUSTION.

When we analyze combustion as ordinarily carried out in practice we find all three of the fundamental processes going on. Coal does not burn as a whole on the furnace grate. The upper layers of the fuel bed undergo decomposition by destructive distillation, liberating 15 to 40 per cent of the coal as volatile gases and vapors, while combustion of the residual material is going on in the lower portions of the bed. Gasification of the carbon to carbon monoxide also constitutes an important part of the burning process, the fuel bed acting as a gas-producer.

Smoke prevention is essentially a problem of proper handling and thorough combustion of the volatile products of the coal; in fact, furnace efficiency is to an important degree dependent on the same factor. The successful and efficient operation of a coal-burning furnace requires an understanding of the nature and behavior of the volatile matter of coal, and especially of that of the particular coal that is used in each case. Something as to the new knowledge of the volatile matter of coal will be presented later, after other methods of utilizing coal have been considered briefly.

CARBONIZATION.

Carbonization, from the point of view of fuel efficiency, deserves a much greater industrial application than is now given it. It enters as a factor to be sure, into all the applications of coal, and in coke and gas manufacture it constitutes the essential factor. But only a small percentage of the coal produced goes into coke and gas manufacture.

In carbonization the coal is decomposed under the influence of heat, without access of air, and the entire substance other than the mineral constituents break down into volatile products and a fixed residue, principally carbon and ash. The volatile matter of the coal here again comes into play as an exceedingly important phase of the process. The manner of the first breaking down of the coal substance as it begins to be heated probably determines in large measure what quality of coke any coal will form. The early or primary volatile products and the kind of heat treatment they receive as they issue from the retort determine the gas and by-product yield of the coal.

Instead of carbonising and burning in a single operation as is done in a combustion furnace using coal, whereby all of the coal and the intermediate products evolved from it are burned for their heating value only, the coke oven or gas retort utilizes the coal more scientifically by converting it into two improved forms of fuel—coke and gas—with a combined heating value about 85 per cent of that of the coal, and in addition thereto saving the intermediate by-products—tar, benzol, and ammonia—which have a chemical value far exceeding their fuel value. The coke and gas can be burned as fuels without smoke and with greater efficiency than the raw coal. A portion of the coke or o the gas, to be sure, must be used to supply the heat for carbonising, this item amounting usually to from 10 to 14 per cent of the original heat units in the coal.

It is not an idle dream to look forward to the time when there will be many central power and heating stations in the form of large by-product coke-oven plants, placed at the mines or near large cities. As influences leading to this end, we may mention the following: modern advances in long-distance transmission of electric power, the increasing demand for and value of coal by-products for chemical purposes, the successful use of coke as a domestic and industrial fuel, the development of the gas engine, and the growth of public opposition to the smoke nuisance.

Low-temperature or medium-temperature carbonization of coal has lately been introduced in Europe on an industrial scale. Coal is heated at 500 deg. to 700 deg. Cent. either under reduced pressure or in a current of auxiliary gas which passes directly through the coal, producing high yields of tars or oils and rich gas in small quantity. These processes depend for their commercial success on the quality of and the demand for the oils and the solid residues produced. Because of their adaptability to the recovery of oils, possibly motor fuels, from coals not heretofore commonly used for by-products, they offer an interesting field for industrial experiment in the United States. In the present commercial situation brought on by the European war the lack of an adequate supply of creosote oil, largely a coal-tar product, is a big incentive to the increase of coal-carbonizing operations in this country. Sufficient coal tar and benzol can be produced from existing by-product coke ovens and gas retorts to supply the present American demand for all other coal-tar products, creosote oil being excepted. But in view of the increasing use of benzol for many purposes and of the growing demand for coal-tar products of all kinds, there is an opportunity for a large expansion of the coal-carbonizing industry in the near future.

GASIFICATION BY PARTIAL COMBUSTION.

The third general method by which coal is used industrially is exemplified in the gas-producer, comparatively a very efficient method of recovering the potential energy of the fuel. Carbonization enters into this process also, since at the top of the fuel bed the coal is destructively distilled before passing down to be gasified by the air and steam from below. The gas producer will be treated thoroughly in one of the succeeding lectures of this series.

Having considered the industrial uses of coal in a general way, we may, to advantage, take up now some of the scientific aspects of the problems and allude to some of the more recent findings in this field.

NATURE OF COAL.

It is of interest to inquire first: What is coal? What is its chemical nature and constitution? A knowledge of this would surely be of great value in promoting an understanding of its behavior; in determining, for example, the explanation of the coking property; the cause of spontaneous combustion, or the difference between coals in liability to dust-explosions in mines. Unfortunately, however, the problem has proven a most difficult one, and as a result of the work of many investigators during the last 20 years or more, little of a definite nature has been determined. We may say without hesitation that coal is a mixture of complex organic substances which are degradation products of cellulose, resins and gums, and vegetable fats and waxes. Free carbon has never been proven to exist in coal, and hydrocarbons are probably not present in an amount greater than 1 per cent.

The problem of the constitution of coal has been attacked chiefly by two methods: (1) Extraction with solvents, and (2) destructive distillation at low temperatures. Extraction, while it has resulted, by use of pyridine, in dissolving and removing 15 to 18 per cent of the coal substance, has not separated any single definite identifiable compound in more than mere traces.

Destructive distillation also has led to no exact results, but it has given, on the other hand, certain well-defined indications of the nature of the substances present. These indications are mainly that coal is made up of a great many complex substances, which have resulted from degradation or decay of plant cellulose, lignose, resins and waxes. These substances in coal are closely graded into one another in chemical nature and composition, except that the cellulose and lignose group is probably more or less sharply distinguished from the resinous group. Within each group are substances in many different stages of alteration by aging. Chemically the cellulose bodies are distinguished by their higher content of oxygen, by their tendency to combine with or absorb oxygen, and by their thermal decomposition into CO_2 and CO, water of constitution, and paraffin hydrocarbons. The resinous constituents, on the other hand, have a higher content of hydrogen, less of oxygen, and decompose by heat into hydrocarbons and hydrogen with small quantities of CO_2 and water. The resinous bodies are contained most abundantly in the coking and mature coals of the Appalachian region.

THE VOLATILE MATTER OF COAL.

The term "volatile matter of coal" is more or less of a misnomer, but serves as well as any other. There is probably little or no material in coal which is volatile without decomposition. What we call "volatile matter" is the mixture of vapors and gases resulting from decomposition of the coal substance by heat. Its composition depends on the kind of coal and also very much on the temperature to which the coal is heated and to which the primary products are subjected. By "primary products" are meant those which form first as the coal slowly rises in temperature. These are, in order of their formation: water, hydrogen sulphide, carbon dioxide, various saturated and unsaturated paraffin hydrocarbons and hydrogen. Many, in fact most, of the commonly known constituents of coal gas, coal tar and gas liquor, such as benzine, naphthalene, pitch and ammonia, are the products of secondary decomposition of these primary products.

The volatile products of coal are not all combustible. From some bituminous coals, completely dried, we obtain by decomposition as much as 10 per cent of non-combustible volatile matter, and from some lower-grade coals even as much as 15 or 18 per cent. So there can be no question that the term "volatile combustible matter" as frequently used is decidedly a misnomer, since from one-eighth to one-half of the volatile matter of coal is non-combustible. It is important to bear this in mind when comparing coals, since those coals having rich, smoky volatile matter are more difficult to burn efficiently than others having a volatile matter possibly greater in amount but containing a larger proportion of inert matter.

An organic substance, of the nature of cellulose, produces water and CO_2 (with CO also) on decomposition by heat. When cellulose itself decomposes at temperatures below [illegible] deg. Cent., 45 per cent of its weight

*Lecture delivered by permission of the Director of the U. S. Bureau of Mines, before the Department of Chemical Engineering, University of Pittsburgh.

appears as water and CO_2 in the volatilized products. So also coal produces these things by decomposition, and the more abundantly the less matured and metamorphosed is the coal. We must expect to find an aqueous liquor distilled from coal during its decomposition, and in fact at gas works and coke ovens such is the case, a much greater volume of aqueous ammonia liquor being obtained, especially in the hydraulic mains (the first condensing point), than corresponds to the volume of the wash water added.

These facts enable us to draw inferences, at least, as to the chemical character of some of the substances in coal. The younger coals, like the lignites and the sub-bituminous coals, must contain large proportions of bodies with —OH or —CHO groupings, like the celluloses, since they produce water and CO_2 so readily; in the more mature coals, like the coking and high grade steaming coals, there are not as many of these oxygen-bearing groups, but, probably, more of certain highly complex long-chain or many-ringed bodies having side-groups of readily separable hydrogen atoms or of alkyls corresponding to the paraffin and possibly the aromatic hydrocarbons. These hydrocarbon groups are set free by heat, and then easily undergo further decomposition into the simple, commonly known products like methane and hydrogen.

The theory of Wheeler (of the British Coal-Dust Experiment Station) and others, that coal contains considerable quantities of certain substances which decompose only above 700 deg. Cent. and yield principally thus hydrogen and the oxides of carbon, is hardly justified by the experimental data at hand. More reasonably is it to be supposed that the large amount of hydrogen produced above 700 deg Cent. comes from secondary breaking down of the hydrocarbons first liberated, and of the partially carbonized solid material left behind, these things not having been present, either of them, as such in the original coal. It is likely that all the organic substance in coal decomposes early by heat, below 500 deg. Cent.

The nature of the substances liberated or volatized from coal by moderate heat throws some light on the coking properties of the coal. If by prolonged heating at 400 deg. Cent. the coal shows little or no tendency to soften or sinter together, and liberates water and gas but only a small quantity of heavy, viscid tar or pitch, it has not good coking properties. Laboratory tests to show coking quality of coals have never been satisfactory. Several are used which give more or less indication but are not definite. Among these may be mentioned (1) heating to a red heat a small sample inclosed in a covered, well-filled platinum box, and examining the coke bar produced; (2) rubbing or grinding the coal in a mortar and noting the tendency to cake or adhere to the pestle and mortar; (3) analyzing for C, H and O and comparing ratios of O to H.

In recent laboratory experiments in Germany cellulose has been converted into coal by subjecting it to very great pressure with moderate heating.

Investigations are in progress at several places to determine methods of increasing yields of some of the by-products of coal carbonization, e. g., the commercially desirable benzol and light oils, through carbonization under carefully controlled conditions, of the tars thus produced.

RATE OF EVOLUTION OF VOLATILE MATTER.

In the utilization of coal, particularly in burning on furnace grates, the rate at which the volatile matter is set free is frequently of greater importance than the total quantity produced. Coals vary greatly in this respect. The following results obtained in the laboratory on three different coals similarly treated (0.4 gramme powdered, air-dry coal heated at 1,000 deg. Cent.) bring out this variation:

Time Per cent volatile matter	5 seconds	5 seconds Total Combustible	30 seconds	30 seconds Total Combustible
New River, W. Va., coal...	5.8	4.8	20.0	17.5
Pittsburgh, Pa., coal.....	9.0	7.5	34.0	28.1
Sheridan, Wyo., coal.....	26.0	12.4	49.0	21.6

It may be seen from these data that while the Pittsburgh coal produces finally more combustible volatile matter than the Wyoming, the latter on the other hand liberates considerably the more in the first few seconds of heating.

The rate at which a given coal liberates volatile matter depends (1) on its chemical character, i. e., its ease of decomposition; (2) on the rate at which heat is supplied to it. The ratio between the quantity of coal heated and the quantity of heat supplied in unit time determines the rate at which any given coal becomes heated. It is, therefore, not a question of temperature as much as of quantity of heat and quantity of coal. When each particle of coal has attained a temperature of 900 deg. Cent. its decomposition into coke and volatile matter is practically complete.

SUMMARY.

Three points stand out as of importance in connection with the volatile matter—the element which is so vital in all processes of coal utilization:

1—The composition as well as the quantity of volatile matter varies greatly among coals.

2—The first products volatilized in the early stages of a coal's rise in temperature are essentially different from the total product as usually obtained. These first primary products are largely tarry liquids, with some water vapor and heavy complex gases. Heating conditions determine the degree of secondary thermal decomposition of these products and the composition of the final gas and tar.

3—The rate of evolution of the volatile matter from coal is of practical importance and varies considerably with the kind of coal. For a given coal it is dependent upon the relation between the quantity of coal heated and the quantity of heat supplied—not the temperature.

OXIDATION, IGNITION, SPONTANEOUS COMBUSTION OF COAL.

Next to thermal decomposition or the evolution of volatile matter perhaps the most fundamental process involved in the practical utilization of coal is that of oxidation or burning of the substance as a whole.

Slow oxidation at ordinary temperatures gives rise to spontaneous combustion and deterioration in storage; rapid oxidation has much to do with the initiation and propagation of coal-dust explosions in mines, and with the relative ease of ignition of fuels in general. The process of igniting a combustible substance is not as simple as it may seem on first thought, and just why some fuels ignite more easily than others requires careful analysis.

At temperatures above that of the first appreciable decomposition of the substance (say 250-300 deg. Cent. in case of coal), the process of combustion is complicated by the distillation of combustible gases and vapors and the alteration of the solid material. The gases and vapors of decomposition are not, however, all combustible, and in fact, those produced from the most readily ignited materials, such as wood, are largely non-combustible. A splinter of wood held in a flame ignites quickly, it is true, because the gases of decomposition are heated to their ignition temperatures quickly. But we can also ignite the wood easily in a glass tube at 250 deg. Cent. by passing a current of oxygen over it. Here the ignition cannot be a matter of distilled gases since the temperature used is much below the ignition points of those gases.

Relative ease of ignition is unquestionably dependent to some extent on ease of oxidation, i. e., the rapidity of the reaction of the substance with oxygen. Recent laboratory studies have shown a wide variation among different coals and other combustible substances in their rates of oxidation, and the variation in this property follows the known variation in ease of ignition, in susceptibility to spontaneous combustion, and in rate of deterioration in storage.

The action of oxygen on coal at ordinary temperatures has been shown by recent investigation to consist not in a burning of the carbon to CO_2 nor probably of a burning of the hydrogen to water, but largely of an addition of oxygen to the coal substance. This action develops heat. English investigators have shown that the calorific effect of this oxidizing action at 40 deg. Cent. amounts to between 2 and 3 calories per cubic centimeter of oxygen consumed—only a little less than that produced per cubic centimeter of oxygen when coal is completely burned (3.0 to 3.5 calories). The rate of oxidation increases rapidly with rise of temperature. A coal which at 30 deg. Cent. consumes 10 cubic centimeters of oxygen per 100 grammes in an hour, multiplies this rate so rapidly from the effect of its own production of heat that the temperature would rise to 180 deg. Cent. in a little over two days if no heat were lost. This would result speedily in ignition if an adequate oxygen supply were at hand.

Spontaneous combustion in stored coal results from this slow oxidation by the air at ordinary temperatures. It is not, in any important degree, a matter of bacterial action, or fermentation. When conditions as to the size of coal and manner of piling are such that the rate of heat produced by oxidation is greater than the rate of heat loss by convection currents and radiation, the temperature rises. One of the most important practical considerations is whether an adequate air supply can penetrate to an inner section of the pile where the heat loss is slow. Fine slack coal does not heat seriously in the interior of a pile, if no lump is present. If, however, the interior of a pile consist largely of fine coal and the outer and lower sections consist of lump with very little fine, one of the worst possible conditions is maintained, and spontaneous fires commonly result therefrom.

Deterioration of coal in storage is due to slow oxidation, not to loss of volatile matter The deterioration in heating value is not as great as has been commonly supposed. With high-grade bituminous and semi-bituminous coals, careful determination has recently shown that this loss amounts to less than 1 per cent in 1 year's exposure to the weather, and less than 3 per cent in 5 years. With our middle-western and western coals or lignites the loss is greater but probably does not exceed 4 or 5 per cent in 1 year in any case. Deterioration in size or physical character may be somewhat more serious, and spontaneous heating even though moderate in degree causes very serious loss. Deterioration of any kind may be quite largely prevented by submergence storage under water.

Much more might be said of the new knowledge of coal, if time permitted; of the different ways in which water is held in the coal substance, of occluded gases, of the fusibility or softening of the mineral constituents at high temperatures, of the forms in which nitrogen and sulphur are combined in the coal and how they behave on heating, etc.

From what has been told, however, it is hoped that some understanding may have been given of the importance of scientific knowledge of coal and its behavior and of the practical bearing of this knowledge on every-day industrial problems.

Bread from Stones

A CIRCULAR entitled "Bread From Stones," written by Dr. C. G. Hopkins of the Illinois Experiment Station, has become an agricultural classic. It is now in its third edition and nearly 100,000 copies have been distributed into all parts of the United States. The circular tells the story of Dr. Hopkins's success in bringing back economically a wornout farm in southern Illinois to profitable production.

The farm under consideration consisted of about 300 acres of poor gray prairie land and was purchased in November, 1903, for less than $20 an acre. It was known in the community as the "Poorland Farm," and Dr. Hopkins adopted that name for his farm. The work of restoration was begun at first on only 40 acres of the farm. This particular 40 was bought at $15 an acre. It had been agriculturally abandoned for five years prior to this purchase. It was covered with a growth of red sorrel, poverty grass, and weeds. The land was sour, dead, and depleted of plant food. During the ten years following the purchase of the farm, the 40 acres received the following treatment:

1903—Fall: Purchased, $15 per acre.

1903—Fall: Applied one ton per acre fine ground rock phosphate.

1903—Fall: Plowed all above under for corn for next year.

1904—Spring and summer: Corn crop.

1904—Fall: Applied limestone, two tons per acre.

1905—Spring: Soy beans.

1905—Fall: Wheat.

1906—Spring: Clover sowed in wheat.

1907—Spring: Timothy and more clover.

1908 and 1909—Meadow and pasture.

1909—Fall: Applied rock phosphate.

1909—Fall: Plowed down for corn.

1910—Spring and summer: Corn crop.

1911—Spring: Oats; volunteer clover appeared.

1912—Spring and summer: Clover harvested.

1912—Fall: Plowed for wheat.

1912—Fall: Applied limestone, two tons per acre.

1913—Summer: Wheat harvested.

Note—Applied six loads per acre of barnyard manure once during the ten years.

Only 39 acres were in wheat, a lane having been fenced off on one side of the field. The yields were as follows:

One and one half acres with farm manure only—11½ bushels per acre.

One and one half acres with farm manure and one application of ground limestone—15 bushels per acre.

Thirty-six acres, with farm manure, two applications of ground limestone, and two of fine ground phosphate in the rotation as described—35¼ bushels per acre.

Here we have a yield of wheat about double the average land of the State. The practical farmer will naturally ask, "What did all this cost?" The average annual cost for the purchase, delivery, and application of the limestone and phosphate was $1.75 per acre. In the ten years, then, the total cost was $17.50 per acre. Add to this the original cost, $15 per acre, making $32.50, and still you have pretty cheap land to produce double the average of the State. Dr. Hopkins puts it this way: "The average annual investment of $1.75 resulted in the increase of 24 bushels of wheat (35¼ - 11½) per acre in 1913. Thus we may say that the previous application of these two natural rocks, or stones, brought about the production in 1913 of 864 bushels of wheat, an amount sufficient to furnish a year's supply of bread for more than a hundred people."

This story of the "Poorland Farm" is a remarkable instance of the conservation of one of our greatest resources, the soil. Conservation means a saving of the resource by a wise use of it. At the end of ten years of use the soil on the "Poorland Farm" is producing more wheat than the average production of the State, and at the same time its fertility is increasing year by year.—*School Science and Mathematics.*

NEW BOOKS, ETC.

THE INDIVIDUAL DELINQUENT. A Text-book of Diagnosis and Prognosis for All Concerned in Understanding Offenders. By William Healy, A.B., M.D., Director of the Psychopathic Institute, Juvenile Court, Chicago; Associate Professor Mental and Nervous Diseases, Chicago Polyclinic. Boston: Little Brown & Co., 1915.

Dr. Healy has been concerned chiefly with discovering the causes of criminality. The purpose of the investigation is not new, but its methods and its results are strikingly new. Every boy is a potential criminal. A mere accident (the death of a parent, poor school associations, sudden poverty) may change his whole career. Healy finds that the problem of crime always harks back to parental guardianship. Parents must be educated as well as their boys and girls. He finds that practically all confirmed criminals began their careers in childhood or early youth. The determinants of delinquent careers are the conditions of youth. Therefore a knowledge of developmental conditions is important. Data about family traits, early characteristics and environments may be worth much in explaining the offender's tendency. Because the best rewards from scientific efforts are to be obtained from working with youth, Healy has confined himself very largely to boys and girls.

Healy starts from no criminological theory, but obtains all the available facts by a combination of the best methods. His introduction of psychological tests is as new as is his application of analytic methods to throw light on covert mental mechanisms and the startling effects, unsuspected or apparently unrelated, of early experience. Very interesting and dramatic concrete examples showing how boys become criminals are cited. Healy is primarily a student of human character, dealing with motives and driving forces of human conduct. Since conduct is a direct product of mental life, he delves into the mind of a boy, reveals its mechanism, discovers why it is functioning in the wrong way and makes the necessary repairs, so to speak. Often the repairs cannot be made because the criminality is due to hereditary forces over which science has no control.

Healy's work vitally affects parents, ministers, teachers and advisers of boys in general. He points out where they are wrong, where they must reform their methods. Incompetent parental control is a cause of delinquency; so are parental immorality, neglect, lack of comprehension, severity, alcoholism, and vice generally.

Apart from its influence on education, Healy's work is of distinct scientific value because it will enable us to frame more rational legislation for dealing with criminals. Society frames laws for the purpose of making the punishment fit the crime, not the individual. Human wickedness is measured by the degree of violence used or the amount of property stolen. Because we consider the crime rather than the criminal, the whole system of penology and the reformation of criminals is ineffective.

Legislators have never framed laws on a basis of scientific fact, partly because such a basis has been lacking. The law's test of criminal responsibility is wrong from every standpoint—wrong from the standpoint of society and wrong from the standpoint of the criminal. Or as one unjailed expert criminal once told Healy: "The only way to stop us is to find out who and what we are and what we are good for. Then you've got to make punishment severe enough or opportunity good enough for us. You don't do either of these now."

There is a great literature of criminology, but nothing directly helpful to those who must deal practically with offenders. Healy has made the first systematic attempt in this country to gather the scientific facts which should form the basis of all legislation affecting criminals. He concerns himself only with workable methods and the possibilities of diagnosis in cases of delinquency. He is absolutely independent of European teachings—notably the now abandoned Lombroso teachings. He has begun what may well be called a new epoch in rational practical criminology. Healy believes in punishment because criminals believe in it themselves, but the punishment must not harm the offender—must not render him socially unfit. He believes more in an honest and studious attempt at interpretation of criminal delinquency, in reorganising the courts for better treatment, in treating the physical and mental causes of crime, in changing the environment when necessary, and above all in honest inquiry. No court machinery, he maintains, can ever take the place of deep humanistic understanding. He indorses the statement of a girl who blurted out to a judge:

"You and your officers are here to do your duty, and I suppose you are going to send me away, but before I go I want to tell you one thing. You don't at all understand me."

How many parents really understand their children?

THE SPELL OF SPAIN. By Keith Clark. Boston: The Page Company, 1915. 8vo.; 439 pp.; illustrated. Price, $2.50 net.

Such names as the Alhambra, Cadiz, and Seville are alone sufficient to prepare us for an Arabian nights entertainment. Mr. Clark and his Dofia approach Spain by way of Arabia, in "the high Moorish fashion of Tarik." It is a quiet triumphant invasion. Out of antiquity emerges the shining present—white houses washed by rosy beams, clambering their terraced heights from blue sea to bluer sky. Thus Cadiz. Very charmingly the pilgrimage leads us along the Spanish roads, over old Moorish bridges, on to the fretted Alhambra. Granada and Andalusia contribute their exquisite plaques to the mosaic of stories charm. It is a pilgrimage the lover of old world life should surely take, in the flesh, if possible; if not, then by proxy. And we can wish him no better guide than Mr. Clark, and no more happy means of conveyance than his easy narration.

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SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, APRIL 3, 1915

Charles Allen Munn, President
Frederick Converse Beach, Secretary
Orson D. Munn, Treasurer

All at 233 Broadway, New York

Entered at the Post Office of New York, N. Y.
As Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876)	per year	$5.00
Scientific American (est. 1845)	"	[illegible]
American Homes and Gardens	"	[illegible]

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SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX
NUMBER 2049

NEW YORK, APRIL 10, 1915

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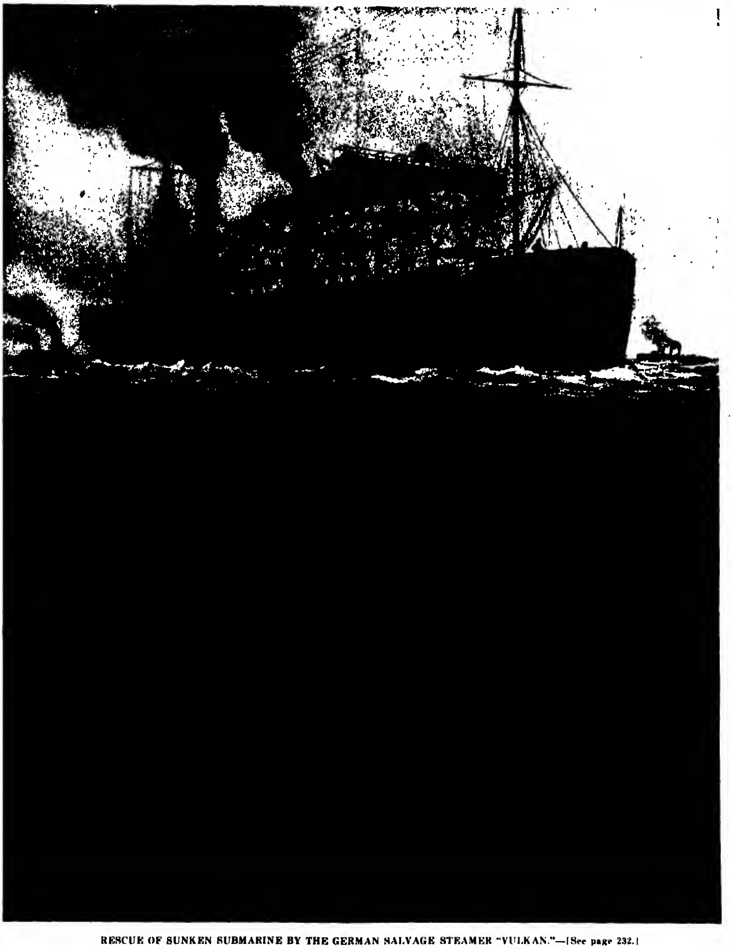

RESCUE OF SUNKEN SUBMARINE BY THE GERMAN SALVAGE STEAMER "VULKAN."—[See page 232.]

The Life-Study of Patients*

The Biographic and Multiple Biographic Method of Discovering Medical Truth

By George M. Gould, M. D.

Most physicians busy themselves with the single illness of which the patient presenting himself complains and medical practice consists almost always of such treatment of the temporary and single complaint. The repetition of the affection at a later time is treated in the same way. There may be some vague connection noted by the physician between the two or more illnesses but at least in cities the rapid elimination of the old fashioned family physician who attended one patient and family for a lifetime is fast making even that perception impossible.

Concurrent affections and those of organs treated by specialists were moreover not noticed and a dozen symptoms of minor diseases were not thought of or were listed as distincts and without causal or related nexuses. If any physician rose to a philosophic gathering of the facts of his individual patient's several illnesses he hardly succeeded in looking over the entire life and subjecting the symptoms and diseases of the whole personality to a rigorous analysis and co-ordination.

Lastly no one has ever thought of bringing a large number of clinical life histories into comparison and producing a composite photograph of the complete pathologic findings. And just this method one would think would have been early seized upon as that certain to bring to view medical truths otherwise remaining hidden from the observer. The method as applied to fourteen patients with one disease has yielded unexpected discoveries and demonstrated a unity of cause and of diverse symptoms that was wholly unforeseen.

The attitude of the world, even of the medical profession, in the presence of disease has been one of fatalism. Indeed the belief in fate one may surmise has been largely due to the strange and mysterious incidence of disease. Why one should be sick and another free from sickness has struck men's minds ever since the riddle of life worried the soul of the boil pestered Job. So long as the physician was concerned with his patient's single and passing (or killing) ailment he gained no large overlook to bring unity into the pathologic problem of a whole life or of a number of lives. And viewing disease as an objective entity studying it from the standpoint of morbidity, infectious or organic, does not yield the same results as in viewing it from the aspect of the patient, the whole life of the patient, and the whole lives of many patients. Take the fourteen mentioned. If one physician could have treated all of them during their entire lives he would undoubtedly have seen that there was some single underlying unity and cause for all their afflictions. But as the single complaint was treated at one time by one or even several physicians and as a hundred were consulted during their lives all the cases remained discrete, mysterious and utterly inexplainable. Moreover looking into the minds of their physicians we find that not one had any conception whatever of the cause and nature of their patients' maladies and not one agreed with the other as to treatment. A peculiarly instructive fact is also this. Many symptoms complained of by these patients were held by both patient and doctor to be merely accidental and concurrent which were repeated in other cases and which were in fact bound by a single cause into a strictly pathologic unity. By the method of focusing the clinical life and a number of clinical biographies into a composite whole new truths at once break upon the observer which were necessarily hidden from the physician of the single day or year, of the single disease, of the single patient and of the single life.

And the method is by no means of value only as to migraine or eyestrain. It will prove, I suspect, to have equally good results in other diseases. The study of clinical biographies will prove as illuminating in the etiology, cure and prevention of many diseases, even in those in which we think all mysteries are explained by bacteriology, histology or other objective methods. Just as the good physician treats his patient and not the disease, so general pathology needs to study the patient instead of, or at least in addition to, his disease. The sick man rather than the man's sickness, his life rather than his single illness, many lives instead of one—that is a method of eliciting medical truth which needs exploiting, and which will in the future bring unexpected light into our pathologic darkness.

In addition I am sure that the results of eyestrain which I have discovered in clinical biographies are by no means all. In private practice I have gained glimpses too indefinite as yet to put on record, of further and possibly of as great influences of ocular malfunction in causing other morbid functions, or in influencing them. No truth is more certain in general biology than that long and oft repeated function begets structure. Inevitably, therefore, functional morbidity must produce organic or structural morbidity. In illustration of that thesis lies much of the progress of future medicine. The study and systematization of long and repetitive malfunction can be made only by means of the method of biographic clinics. That study largely lies in the hands of the family physician, when he will rise to his opportunity.

Our first surprise in these fourteen biographic studies is that there have been so many sufferers. Without any extended search, and merely incidentally, I have, in all found nearly a score of literary, scientific, or musical geniuses who were hardly suspected of having been so grievously afflicted. In their biographies were also allusions to many of their friends or distant contemporaries patiently enduring the insults of the same disease. And when one looks into the history of the disease as chronicled in medical literature it is plain that from the earliest barbarism to the latest civilization a large portion of humanity has had the same disease. In medical practice the physician finds all over the world the malady tremendously prevalent and rapidly growing more frequent and more terrible in its life-wrecking consequences. One's amazement is beyond expression when, lastly, it is found that this disease of untold millions of the past and of others now living is a confessed mystery to science. Its very name is an absurdity—the non naming of a trivial symptom generally not present of a disease, the very organs affected being unknown, the symptoms indescribable, the cause unknown, the nature unknown, and all treatment absolutely resultless. This bizarre condition of scientific impotence is rendered still more farcical by the fact that, except in one case, not a patient of the fourteen nor a physician of their hundreds recognized the disease before them. They were utterly mystified and did not even call it by any name. Even Nietzsche argued with his physicians that his terrible disease was not one-sided or hemicrania.

The fact of the extreme diversity of the symptoms of the fourteen patients, of itself prevented their physicians from recognizing the single cause to which they were due. The nearest they came to it was a half glimpsed, vague, and passing adumbration of the truth. It was in part a sort of flattery of the patient, usually by himself originally, that begot the theory that brain working caused suffering. The hundreds of columns of twaddle about "brain fag" in the London and American newspapers in October, November and December, of 1903 show the existence of the same superstition. A thousand brain workers have "brain fag," but another thousand do not. It is plain that the explanation is badly in need of explanation. Intellectual work does not produce disease or suffering any more than muscle work. Evolution has made no such stupid blundering as that.

But muscle work with organically diseased muscles or blood making organs does produce trouble, and just so brain work with morbid nervous organs may, and must beget morbid results. The physicians of our fourteen patients never once asked if any of the organs put to such frightful labor by the intellect were abnormal. The study of the biographic clinics of these patients at once shows that the greatest, most delicate, most complex, most intellectual sense organ is, in literary activity put to the greatest labor. Physiology long since demonstrated that in a large number of these eyes, their anatomy is imperfect, their function pathogenetic. The old truth will never be sufficiently well learned that morbid physiology is the source of pathology, that malfunction precedes and begets organic disease. This is forgotten in the avid study of the end products of disease and of the disease itself instead of the diseased patient.

The great error that intellectual or literary work *per se* produced the diseases of our fourteen patients resulted in the rule of life, learned from experience, or half taught by the desperate physician, to get into the open air. Thus these patients found it wise to "take a trip to Switzerland," "to go to Italy," "to walk the moors," to take a vacation," "to run down to the Riviera," "to climb mountains," "to go on a jaunt to the seashore," etc. Often the greater part of patients' lives was spent in this way. The success of this empiric therapeutics was undoubted, but only so long as the out-of-door life was continued. With the return to sedentary life the old troubles at once resumed their sway. We now know that eye work, not intellectual labor, was the cause of the disease. But a thousand articles and books on "migraine" written during 300 years came only so near the truth as the suggestion that migraine affects chiefly the educated and intellectual classes. And even this statement is not true, because it affects all eye workers in equal degree, whether they are readers, thinkers, littérateurs, etc., or simply sewing women, typewriters, and handicraft laborers. The fact suggests that with the older physicians their well-to-do patients were their chief concern, and the poor were relatively ignored. But the poor have the aristocratic disease just as frequently—if they use their eyes within reading and writing distance as incessantly as the students. The presence of astigmatism has nothing to do with the social or intellectual status, although it had much to do with the physicians' reports of cases, etc. The walking cure as it may be called was learned by bitter experience and usually by the patient himself without the assenting advice of the puzzled doctor, who did not know what else to do.

The demand of the tormented system for walking and physical exercise is in astonishing evidence in the lives of nearly every one of the fourteen patients studied. It undoubtedly dictated the "Beagle" and the "Rattlesnake" voyages of Darwin and Huxley, it drove Parkman to a fury of athleticism that was ruinous and was the direct cause of the aphorism style of Nietzsche. In every one it took a peculiar coloring but move they must or they would have gone mad as Wagner said of himself.

The clearest medical advice to the migrainous "brain worker," the "brain befagged," the neurasthenic, etc., was that the stomach and digestion were at fault. Diet became the will-o-the-wisp, which engendered a thousand cookery books, systems of diet, food rules, fads, institutions, cures and crankeries, in reference to eating and drinking. All Europe seemed largely ordered by the needs of patients worshipping or bringing offerings of time, wealth, and lives themselves, to the altar of the great god dyspepsia. All this was because in a certain or uncertain proportion of cases the digestion was less or more disordered by "migraine." No one has ever agreed with another as to what constitutes the symptoms of the disease migraine, but some migrainous sufferers have nausea and vomiting or other dyspeptic symptoms. That the superstition that these secondary gastric symptoms are primary and causative still rules the lay and professional mind, is demonstrated in every textbook and article written on the subject. The hundreds of "brain fagging," "brain fag" correspondents of newspapers of the last few months show how living is the old idolatry.

"Migraine" and "brain fag" are caused by astigmatism but eye strain causes many other morbid symptoms than those grouped under the non-signifying and misleading terms. In no textbook on diseases of the stomach or of the digestive organs will one ever find a word as to eyestrain, and yet eyestrain possibly causes more of the diseases of digestion than all other causes combined. The study of the patients' single disease, or of the disease itself, would never have revealed this truth. Only the life histories of the suffering patients make the fact apparent.

It is noteworthy how frequently proverbial and empiric wisdom forefelt the lessons here emphasized. One of Lincoln's maxims was, "Keep your digestion good, steer clear of the biliousness." Sir Benjamin Ward Richardson said that the would-be centenarian among other things should "work as little as possible by artificial light." Von Moltke, Sir James Sawyer, and many others, have advised strongly, regular out-of-door exercise. Dr Diet, Dr Quiet, and Dr Merryman, are old and famous physicians. The existence of the large number of spas, health establishments and resorts, cures, hydropathic institutions, sanitariums, and the periodic migrations to Italy, Switzerland, and sunny climes, where out-of-doors life is encouraged, are all to some extent the products of eyestrain.

Most suggestive is the fact that these establishments, whether frivolous and fashionable, or scientific and curative, are based upon a regime which stops near use of the eyes. How fashion does this need not be set forth. Take the best instance of the best class of these "waters" or "cures"—Carlsbad. In the first place

* American Medicine

the old superstition that there is anything mysteriously or miraculously therapeutic in the water itself is worthy of the days of opera bouffe, and it is far more wonderful that the humbuggery has been accepted by the world, lay and medical, so long. If one, any place in the world, will dissolve 15 grains of sodium bicarbonate and 25 grains of sodium sulphate in a pint of water, it would have all the therapeutic value of the Carlsbad spring. Add some citrate of lithia, and it would be far better than any spring water yet discovered. The cunning commercialism that sells water, the commonest thing in the world, at the price of wine, will probably not be extinct for centuries to come. That is the sugar of milk placebo which fixes the attention, while several other really important things are demanded with military authority: 1. A diet which lessens the stored energy of the organism. 2. Baths and other measures which increase metabolism. 3. An amount of walking and exercise that increases the outgo of force in normal or physiologic methods.

But note the ignored and revelatory fact implied in all this: All three methods reduce the excess or overstock of fat and nervous energy which is the basis of "gout," etc., but while they do this they absolutely prevent near use of the eyes. The "walking cure," the rest-of-the-eyes cure, that every poor eyestrain and migrainous patient has found by bitter experience so necessary, is the *sine qua non* at Carlsbad.

The diseases of eyestrain all show an excess of nervous energy, and all are dependent upon near use of the eyes. All are cured by draining off the excess of innervation through physiologic channels (walking, athletics, etc.), and stopping near use of the eyes. It is most suggestive and noteworthy that what cures "gout" cures the hundred sequels of eyestrain—and *vice versa!*

Eyestrain has a peculiar and powerful irritant action upon the nervous system. It begets a hundred differing results according to the nature, needs, and necessities of the individual, but all are summarised as an excess of innervation. Hence the demand of the organism for relief from the morbid stimulus, and for an outlet of the overflow by means of muscular action. Thousands of quotations could be adduced to show this. In addition to the two reasons given above, the eyes demand that (partial) rest only to be secured by the cessation of "near work," such as is gained in walking, etc.

All the treatises on migraine have failed to note this fact or its philosophy, and yet it is a symptom that is most characterizing and significant. It often governs the life, and make or mars fortunes and dispositions. Upon it turns the whole success or failure of ambitions, and it surely colors and controls the quality of literary works as none other. This is at once manifest in the study of nearly all of our fourteen patients, and daily stands plain in the confessions of patients in the physician's office. It engendered a state of excitement and tension in them which had an injurious effect on personal character, and on the matter, styles and judgment of their writings. This is painfully evident in most of the fourteen, but rises to positive morbidity in Carlyle, Wagner, and to ruinous extremes in Nietzsche.

It is impossible, says George Eliot, for strong, healthy people to understand the way in which malaise (her euphemism for sickheadache) and suffering eat at the roots of one's life. It is at first sight strange that eyestrain may produce in some patients sleepiness, dullness, etc.—pure inhibitory effects, while in others the nervous system may be driven to a fury of irritation. Thus in the cases of George Eliot, Whittier, and Darwin, there was the most painful lassitude and exhaustion, while in Carlyle, Wagner, Nietzsche, etc., there was a morbid hyperesthesia and activity. Often both conditions may alternate in one patient. Although George Eliot was usually dejected, depressed, and tired, she speaks of "the excitement of writing," and the mechanism is seen in many sentences as, "My idle brain needs lashing." In Wagner, eye work usually produced feverish intensity and irritability, and yet he says, "Sometimes I stare at my paper for days together." But it is true, as he says, that exaltation was the rule and ordinary calm abnormal. Hundreds of poignant quotations would vividly demonstrate this. In the same way Carlyle had to work with his "nerves in a kind of blaze," "in a red hot element," "with his heart's blood in a state of fevered tension," "in a shivering precipitancy," etc., and yet sometimes it was inhibition instead of hyperesthesia, and he sat at his desk, stared at his paper, his imagination would not work, etc. Writing stirred Mrs. Carlyle's head to "preternaturalness," and always finally exhausted her. It "stirred up" Parkman's head, produced "a highly irritable organism," and he stopped to avoid greater troubles, as did also Spencer. But in Nietzsche it drove the sufferer to "a horrible earnestness," "a nervous excitability," "an undesirable spasming," "a subterranean fire," etc. To use his own words, "The vehemence of the interior vibrations was frightful." It drove Darwin to the sand-walk and De Quincey to opium. In almost all it produced melancholy, helplessness, and despair; made physicians think Parkman and Wagner and Nietzsche were insane, made several believe death was at hand, begot the resolve of suicide in Wagner, and directly caused the cerebral paralysis of Nietzsche. With the biographic overlook one realises that this hyperexcitation and torment of the nervous system caused by eyestrain demonstrates a causal unity of the whole consequences of athleticism, walking, dieting, touring, hydropathising, irritability, diseased literature, melancholia, pessimism, and general morbidity.

Colds, influenza, etc., are not alluded to in the treatises on migraine, and it is only by the study of the life-records of migrainous patients that the truth becomes manifest that inflammations of the mucous membrane of the upper respiratory organs are often caused by eyestrain. In the individual illness or even individual patient, the relation is overlooked. Like a dozen other diseases, the common cold or grip is looked upon as a stroke of fate, and to be accepted without curiosity as to the cause. But even a crude science is finally driven to the supposition of a non-discovered cause mysteriously at work. Whatever role the micro-organism may play, the "soil" (as always) must be prepared. All rhinologists now admit that some mysterious cause is at work. One great physician writes of colds and influenzas that "they may be due to micro-organisms, or local conditions in the air passages, but these maladies, as we now know, both depend to some extent on a special predisposition in the sufferer, having its root in the nervous system, and both leave their stamp on that system and gradually undermine it." And only biographic clinics show that eyestrain is one of these frequent "special predispositions of the nervous system." The seemingly illogic incidence of these inflammations of the mucosa in some patients, and the escape of others, is, at least in part, explained by the fact that when the ocular reflex expends itself continuously on one set of organs, especially those of the digestive system, other organs are freed from the attacks. Thus Carlyle, Huxley, Margaret Fuller, and Darwin have no colds, De Quincey but few, Whittier, Lewes, and Browning, more. Wagner saw some connection when he wrote, "my catarrh has developed so that I may hope it will rid me of my usual winter illness." Nietzsche was tormented with colds, hoarseness, etc., all his life, and Mrs. Carlyle and George Eliot seemed never to have been without influenza, grippe, sore throat, etc. In private practice the relation of influenza, colds, etc., to eyestrain, has often been noticed. Colds alternating with the other symptoms, freedom from the one set replacing suffering from the other, has been noticed. And colds, also, as a terminal affection, i. e., upon the more permanent disappearance of other symptoms, are especially noteworthy. George Eliot's only disease on the day of her death was supposed to be laryngeal sore throat. Lewes also died a day or two after taking cold.

After I had several times noticed the strange manifestation of peculiar and unaccountable eczemas, rashes, etc., as the terminal stages of ocular headaches and of sickheadaches, I found in the reports of some old physicians a clear statement that "herpetisms" were sometimes reported as the sequels of migraine. Modern authors treating of migraine know nothing about this. Wagner had repeated attacks of a "cutaneous malady," and "continuous attacks of erysipelas" which tormented him much of his life. I remember especially one patient who had most distressing attacks of "hives," and various other eruptions, pronounced by the best dermatologists atypical, and which were puzzling to them, and intractable. These attacks were sometimes called acute urticaria, psoriasis, generalized eczema, pityriasis rosacea, etc. In looking back over her life, this very intelligent patient now remembers that the eruptions were always connected with extreme use of the eyes, headache, and especially sickheadache. All of these symptoms in her case have since been repeatedly demonstrated to be due to eyestrain. They recur with leaving off the glasses, and are relieved at once by proper correction of the eye defect. Since the above was written, a most carefully observed and excellently reported case has been called to my attention. It was in the practice of Dr. Charles A. Oliver, and published in *The Philadelphia Medical Journal*. The repeated demonstrations that the urticaria was absolutely caused by eyestrain is most convincing. Observations would doubtless prove the sequel more frequent than is supposed.

Older authors writing of migraine also emphasise the fact that pareses, partial paralyses, anesthesias, disorders of sensation, etc., are frequently complained of by patients suffering from migraine. The most common of these symptoms appear to be paresis, numbness, and tingling (as of "pins and needles") of the hands and arms, extending to the neck and throat, with temporary loss of speech and confusion of ideas. Nietzsche, Wagner, Mrs. Carlyle and others, had similar symptoms, called "rheumatism" by biographers, patients, and physicians. One wonders how many such patients have suffered from such "rheumatisms." There is not a little mystery about the "gout" of Lewes and about Parkman's lifelong articular trouble and lameness.

There is one important symptom of migraine that has almost universally been omitted by the writers of text-books, but which is present in almost every case of the disease, and in all cases of severe eyestrain. This is insomnia. Every one of the fourteen patients whose cases are reported in "Biographic Clinics" complained of it bitterly, and of most the inability to sleep was the chief of all complaints. In the case of the individual illness of a single patient the physician overlooks the symptom; in the life-histories it appears with pitiful reiteration.

There is one other symptom often alluded to by the patients of biographic clinics, which is frequently spoken of by patients in the oculist's office. Beside all those complaints that can be named or described, there is a nameless and indescribable suffering that often afflicts them as powerfully as the localizable and describable ones. They tell you they cannot tell how they suffer, nor where. It is "dreadful," "horrible," "inexpressible," etc., and it is real. That is all they can say.

According to the older conceptions, migraine was an absurd name of a trivial symptom, not generally present, of a disease beginning with the trephining savages of barbarism, widely prevalent in all human history, and vastly increased both in severity and numbers attacked by every advance in civilization. It is to-day wrecking millions of lives and ambitions, often making of them tragedies of needless suffering. The cause and nature of the disease is utterly unknown, and even its location, or the organs in which it is seated, are also unknown. The very symptoms are indescribable, and reporters and writers differ greatly as to what they are. There is no treatment whatever that cures, none that even relieves. Thus the profession stands to-day impotent before its opprobrium, and despairing of resolving the mystery, has turned its back upon it, eager only to explain some organic or infectious disease that does not cause a hundredth of the suffering that is due to migraine.

And yet a glance at the actual and entire life of migrainous patients, and especially of several such lives, would at once have revealed the secret. Few cases, or perhaps no cases of the disease ever occurred except as a consequence of near use of astigmatic eyes, and every case is curable or at least preventable by proper spectacles.

It goes without saying that in the organism wrecked by a life of suffering, all reaction is killed; such cases, however rare, exist, and cure of them is impossible. But even in them some alleviation or change of symptoms is wrought by proper glasses. There is also, rarely, a habit of disease which is hard to break up, although in migraine it is usually to be construed as an unconscious confession of lack of skill in refraction. Migrainous diseases are especially easily controlled and are almost always extinguished even in the most severe and long-continued instances.

Moreover migraine is only one of the many results of eyestrain. The word should indeed be abolished, as it is utterly meaningless. Its two chief symptoms are headache and sickheadache, and these words should be used instead of migraine. When such symptoms are caused by evident organic, local, or systematic disease, there can be no mistake in the diagnosis. Yet even in such cases the pseudoeyestrain symptoms, and also in the socalled "mimicries" of eyestrain, scientific spectacles will probably produce an alleviation or modification of the symptoms that is most noteworthy.[1]

The continuance of all migrainous or eyestrain diseases indeed emphasizes the great need I have previously urged[2] of a systematic and periodic re-examination by scientific specialists, of the bodily organs and functions throughout life. Apart from the objective scientific value of such tests, they would often reveal, and thus prevent further ingravescence of pathologic conditions and trends, of profound value to individuals and families.

[1] But it must be remembered that the vast majority of so-called refractions is worthless. In Europe all refraction may be said to be unscientific, inaccurate, and without power to cure the symptoms and sequels of eyestrain. If attempted by objective methods alone, if done without a mydriatic in those under 50, if anisometropia is ignored—if the most absolute accuracy is not secured in estimating the least astigmatism, etc., the work is without therapeutic value. There are at least 68 reasons why glasses may prove incapable of curing the diseases caused by eyestrain.

[2] "A System of Personal Biologic Examinations the Condition of Adequate Medical and Scientific Conduct of life." *Jour. Amer. Med. Assoc.*, July 21st, 1900.

Republished in SCIENTIFIC AMERICAN SUPPLEMENT, No. 2044, for March 6th, 1915, page 146.

Influence of Radio-Active Earth on Plant Growth—II*

Facts Indicated by Practical Experiments

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Concluded from Scientific American Supplement No. 2048, Page 218, April 3rd, 1915

Operations at the Northfield farm were greatly handicapped by the heavy rains of March, April, and May, which delayed planting for more than a month beyond the proper time, and which later drowned portions of the crops in low places. Later severe drought caused further injury. Many of these results are, therefore, not yet available, but the growing crops, which I have observed with great care on various occasions, have shown results in all respects similar to, but greater than those recorded at my Nutley plantation, which I shall now describe.

The powdered radium ore tailings were applied to the land in the proportion of about 25, 50, 100, and 200 pounds respectively, to the acre. This meant, on plots of 5 by 20 feet, only 1, 2, 4, and 8 ounces, amounts inconveniently small for uniform distribution. Therefore,

Plan of set of plots.

to each such portion 8 ounces of ordinary fertilizer was added and very thoroughly mixed by steam power. This mixture made of the tailings a sort of radio-active fertilizer, for which the symbol R A F will here be used although the figures stated will actually represent the amount of the tailings contained therein.

A field having an area of one and one-half acres was secured and surrounded by a high fence to prevent possible interference. Half of the ground formed a gentle slope to the east, the remainder occupying the level above. The ground was a light, decomposed sand-shale and was moderately stony. Through this plot, from east to west, was laid a road 6 feet in width. On one side the strip was 114 feet wide, on the other 78 feet. The whole set was divided into 34 sets, each of 5 plots.

One plot, AA, was treated with R A F at the rate of 200 pounds to the acre; another, BB, with 100 pounds; a third, CC, with 50 pounds; DD, with 25 pounds, and X with none, although it received the 8 ounces of fertilizer. Each set of plots was 19 feet wide, and the plots composing the sets were, respectively, 5, 13, 9, or 20 feet by 19 feet, according to the nature of the crop. Each plot was separated from those on its four sides by paths 3 feet wide, except for the central road, which was 6 feet wide. As will be seen from what follows, this 3 feet was too narrow a separation to prevent the rays of the radium from reaching every plot on the tract and modifying its yield.

Each plot of a series received exactly the same amount of the same kind of fertilizer, applied at the same time and in the same way. Every operation of seeding, hoeing, cultivating, etc., was performed across all 5 plots at once. Thus, if rain or other condition caused interruption, no plot would have any advantage or disadvantage as to time over any other. In short, absolutely no difference existed in the conditions affecting the growth of plants in the 5 plots of a series, except as to the amount of R A F that was applied.

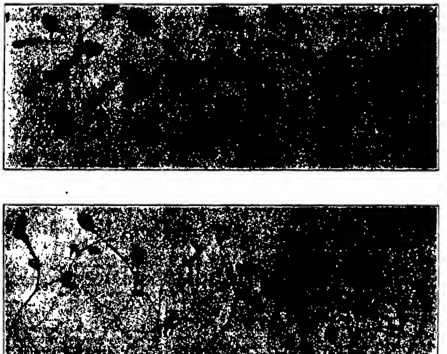
In all but one case, the R A F was sowed equally over the surface and then dug in. In this one case, part of it was put in the rows, in order that a comparison of results might be obtained. When some of the early crops were harvested, the ground was again dug, and other crops planted. More fertilizer was then applied, but in no case was any more R A F added. The R A F in the soil was, however, much more thoroughly distributed by this second digging.

That the 3-foot path was not sufficient to prevent the emanations from crossing and affecting the adjoining plots is fully proved by the observations which follow. A 5 by 19-foot plot of turnips, not treated with radium, lying just north of one treated with 25 pounds R A F to the acre and having the rows running north and south, shows the plants at the southern end of each row, and, therefore, separated by only the 3-foot path from the 25-pound plot, twice as large and strong as those at the northern ends. The graduation in size from the large to the small plants, in all 10 rows, is almost as regular as though produced mechanically. There is an exactly similar difference among the turnips in the 25-pound plot, those at the southern ends of the rows, separated by 3 feet from the 50-pound plot, being twice as large as those at the northern end, with the same regular gradation. Between the 50-pound and the 100-pound plots there is little difference, showing that 50 pounds produces about the maximum effect on turnips.

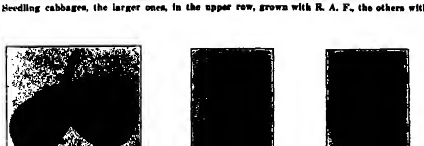
Between the 100- and the 200-pound plots, however, there is a similar but reversed relation. The turnips in the 200-pound plot are stunted by an excess of R A F, just as was the spinach that occupied the same plot in the early spring. Now, the plants in the 100-pound plot, lying across the path from the 200-pound plot, are similarly stunted, while their size increases regularly from that side to the north side, where they are as large and fine as in the adjoining 50-pound plot. In the series of plots next to the west, the celery plants show exactly the same series of differences as do the turnips.

Had I performed no other experiments than these this year I should have regarded the results as conclusive, since there is no other possible cause for the differences in the plants than the effects of the different amounts of R A F. It is in this way that I explain the wide difference in the extent of the gains by R A F at the Northfield farm and those at Nutley. At Northfield the plots compared are acres in extent, so that the radio-activity from one could affect only a very narrow strip of the other, and the difference in weight of crops would show the full difference in activity of the radium. At Nutley, on the other hand, no plot, even though no R A F was applied, was entirely free from radium influence, which

* From a lecture delivered at the New York Botanical Garden on November 14th, 1914, and published in the Journal of the Botanical Garden.



Seedling cabbages, the larger ones, in the upper row, grown with R. A. F., the others without.



Branching of fruits of egg-plants and carrots on plots treated with 200 pounds R. A. F. to acre.

Chrysanthemum plants grown in Phipps conservatory, at the left with R. A. F., at the right without.

increased its yield above the normal, and decreased the differences between it and the radium-treated crops. It has been suggested that the effects on the crops were due to the uranium contained in the R A F, because of the very small amount of radium present. Except in part, this is obviously impossible, since the uranium could affect only the plot in which it was placed. The only possible substance the influence of which could cross the path to the neighboring plot is the radium.

All these results are permanently and indisputably recorded by a series of photographs, which display with great accuracy differences between the respective plots.

Nearly all, if not all field crops gave an increased yield under the influence of the proper amount of R A F. The largest gain recorded at Nutley was 120 per cent; at Northfield 135 per cent.

Probably the yield of all crops will be decreased if a sufficient excess is applied. In most of the cases, such excess was not reached by the 200 pounds R A F to the acre, although in most cases the greatest gain was attained by a smaller amount.

The amount of radium required for the greatest results differed with different crops.

AA was best in 5 cases.
BB was best in 8 cases.
CC was best in 5 cases.
DD was best in 11 cases.

Families of plants showed the same varying susceptibility. Members of the Cruciferae or mustard family, comprising mustard, rape, cabbage, cauliflower, sprouts, kale, kohl-rabi, turnips and radishes were greatly benefited. So were the Cucurbitaceae, comprising the pumpkin, cucumber, squash and melons; in fact, more so than any others. The Gramineae or grass family, comprising hay, corn, sugar cane, sorghum and lawn grass, was enormously benefited. In this connection, it is to be noted that lawns have been peculiarly benefited, because of the special activity of radium on young growing leaf tissue. It is also to be noted that all observers have remarked on the great effect in improving the showiness of flowers.

The effect of the R A F on a second crop on the same ground was greater than on the first. This is probably due to the more uniform diffusion of the R A F through the soil, caused by continued tillage. The essential fact regarding the action of the radium is that each particle is shooting its rays in all directions through the soil. It is therefore to be expected that more uniform diffusion would produce greater results. This teaches the importance of working the R A F through the soil.

The effect upon germination, when small amounts are used, was to increase the percentage of seeds germinated and to accelerate the process.

The earliest effect of radium is to increase the root growth. Often the stem growth will be retarded for a time, but will later undergo a great acceleration.

A given amount of sunlight has produced a greater amount of growth when radium was used, and the same amount of food production has resulted from a smaller amount of green tissue in case of the green-house radishes.

An increased tendency to branching has been observed when a large amount of R A F is applied to the soil.

Perhaps the most important effect of the radium was that of improving the edible properties of the products. Potatoes were more mealy. Root crops were remarkably tender, sweeter and of finer flavor. Beets, carrots, onions, sweet corn and similar vegetables were markedly sweeter. Tomatoes were also sweeter and chemical analysis showed them to contain less water and more sugar. Radium-grown beans and peas were sweet.[1]

My plots of lettuce, after being planted out, were visited by a severe frost which either immediately or very shortly caused the death of a number of them. The percentage of death in the several plots decreased with the amount of R A F present.

The results of experiments with turnips are of greater interest and perhaps of greater importance than any others secured. Two varieties were planted, one the cowhorn, which produces a long slender root like a carrot and the other the white globe, producing a short rounded root, half or more of it borne above the surface of the ground. These varieties were selected in order to ascertain whether the longer variety would show a greater effect from the action of the R A F, as I had previously found true of long radishes as compared with small round ones, in which case the latter showed only 2 or 3 per cent increase over the control plot, while the former showed 70 per cent in merchantable radishes and 40 per cent in total.

In the case of the globe turnips I collected 11 pounds from the control plot and 15 from the BB plot, a gain for the latter of about 36 per cent. In the case of the long turnips, I harvested 14 pounds from the control plot and 32 from BB, a gain of about 129 per cent. These two instances go far toward indicating that the larger the amount of root buried in the soil, and thus exposed to the action of the emanations, the greater will be the gain in that crop. This result agrees with theoretical considerations. It has been established that the entire plant, and more especially the root, becomes radio-active and that this activity resides in the contained water, which would naturally impart a greater activity to that one with a larger root surface buried in the soil, where it can absorb the radio-active water, this water continuously stimulating all the cells with which it is in contact.

There are other interesting considerations in this case. The season of turnip growth, from late August to middle October, was this year marked by an almost total absence of rain, so that the crop was practically a failure. At the time of collection, October 14th, the foliage on the control plots was completely dead and dry. The DD plot of cowhorn turnips was almost as bad while the other three, especially the AA plot, were successively less damaged, having more or less green foliage and being

Row of turnips from control plot; those at left favorably affected by emanations from adjoining 25-pound plot.

Pumpkin.

Delicious squash.

Hubbard squash.

Watermelon

The weight of each fruit at the right bears the same ratio to that at the left as the total weight of the radium treated crop bears to that of the control.

Comparative growth of seedlings of cabbage and tomato, with (at right) and without (at left) R. A. F.

[1] This increase in sugar content, however, has not been found uniform. A number of the vegetables produced at the Northfield farm were subjected to chemical analysis, without finding any noteworthy or characteristic change in composition.

TABLE 1.—Showing pounds produced from plots variously treated at Nutley Plantation.

	AA, 200 Lbs. RAF to acre	A, 100 Lbs. RAF to acre	B 50 Lbs. RAF to acre	C, 25 Lbs. RAF to acre	X, No RAF	Per Cent of Increase Over X: AA	A	B	C	X Over Next Best
LEGUMINOSAE										
Telephone peas	20.9	21 15	23 11	19 4	22			8.		
Nott's peas	13 11	18.	13.2	20 6	16 10				22.5	
String beans	33 10	35.2	32.7	30 14	31 11		11			
Lima beans	68	92.	81 5	93.	79 5				17	
CHENOPODIACEAE										
Spinach	4.3	9 12	11 14	16 1	15 5				5	
Beets	133.	132.	133	126	133	All equal				
SOLANACEAE										
Potatoes	48.	56.	65	64.	61				8.2	
Early Tomatoes	181	270.	309	293.	330.					7
Late tomatoes	169.	226.	242.	213.	267					10
Egg plants	160 (1.9) ea.	160. (1.7 ea.)	118. (1.7 ea.)	120. (1.9 ea.)	153	4.5	4.5			
Early peppers	14.	28.	24	28.5	29					3.5
Late peppers	18.5	16.	13.	12.5	13.	42				
CUCURBITACEAE										
Cucumbers	(8.15 (5 oz. ea.) (4 15 small	7.7 (3.8 oz. ea.) 5.8 small	9 12 (4.5 oz. ea.) 4.14 Small	10 1 (3.8 oz. ea.) 3.15 small	7 14 (4 oz. ea.) 5 10 small				35.7 5.4 tot	
Pumpkins	277 (6.9 ea.)	243 (6.4 ea.)	321 (7.1 ea.)	223 (6. ea.)	206 (5.1 ea.)			56		
Hubbard squash	185. (7.7 ea.)	232 (8. ea.)	150. (200) (6.8 ea.)	100 (133) (6.7 ea.)	161 5 (7.7 ea.)		44			
Watermelons	370. (19 ea.)	340. (9.75 ea.)	378. (11 33 ea.)	333. (8.12 ea.)	260 (8.25 ea.)			27.7		
Delicious squash	217.	233	226.	258.	188.				35.5	
Hackensack melons	87.	100	116.	68	71.			50		
Rocky Ford melons	30.	83	72	50	46.		40			
CRUCIFERAE										
Turnip radish	54.1	57 4	64 10	66 10	64 7				2.5	
Long radish	....	81.3	78.1	70.5	58.		70			
Early cabbage	384. (3.2 ea.)	412. (3 4 ea.)	380. (3 1 ea.)	390 (3.3 ea.)	349 (4 ea.)		18.			
Late cabbage	460. (4.8 ea.)	404 (4 6 ea.)	438. (4.7 ea.)	420 (4.3 ea.)	408 (4 4 ea.)	13 6				
Flat turnips		15.			11		36			
Long turnips		32.			14		129			
GRAMINEAE										
Late corn	81 (0 55 ea.)	80. (0.6 ea.)	90. 0.56 ea.	95 (0.61 ea.)	63 (0 42 ea.)				50	
Early corn	95. (6 oz. ea.)	92 (3.3 oz. ea.)	90. (5 7 oz. ea.)	95 (5 5 oz. ea.)	88. (5 5 oz.)	8.			8.	
UMBELLIFERAE										
Carrots	85.	104.	138.	118	111			24		
Parsnips										
Celery										
LILIACEAE										
Onions	33.				24 5	35				
COMPOSITAE										
Lettuce	32.12	31.	26.12	34.5	26 9				20	

still in a growing state. Therefore, had the time been extended, the percentage of gain over X would have been still greater than that now recorded. On the other hand the conditions and the results are now abnormal, and we probably could not expect such large differences under ordinary conditions.

As to the round turnips, the same difference existed, although in somewhat lesser degree. This again brings us to the consideration of the influence of radium upon the plant's resistance to drought. It indicates quite clearly that the effect of the radium is to increase such resistance. In the case of my egg plants, however, it appeared to decrease such resistance. The latter result appears somewhat contradictory of the effects upon the plant's resistance to frost. The injury to the plant, and the nature of such injury, from frost, is closely akin to that from drought, and as we have seen in the case of lettuce, radium appears to increase resistance to drought. It is possible that this discrepancy is due to the fact that the turnips continued to grow where the seeds germinated, while the egg plants, of rather large size, were attacked by drought just after they had been transplanted from the seed bed.

Some little light has been thrown upon the effects of radium upon plant diseases. The early part of the season was very wet, and the tendency to blight in cucumbers, squashes, and muskmelons, to smut in sweet corn, and to fruit rot in eggplants and tomatoes was rather marked. The damage in the radium-treated plots was not the same in the different crops. Cucumbers and squashes appeared to suffer most where there was most R A F, the melons where there was none. Early corn (Golden Bantam) suffered about twice as much from smut where there was most radium as where there was none, while late corn (Country Gentleman) showed little difference in the different plots.

This is probably the reason for the small percentage of increase in the crop of Golden Bantam as against 50 per cent increase in Country Gentleman, from the effects of the radium. Had all smutted ears from the former been good, and therefore weighed with the others, the yield from the R A F plots would have been much greater.

Tomatoes and eggplants suffered very little from rot on the heavily treated plots, but severely where there was little or no R A F. In the case of eggplants the ratio of damage on the different plots ran almost exactly the same, but inversely, with the amount of R A F applied.

One of the most interesting observations referred to the activity of cut-worms upon cabbage plants. Both early and late cabbages were heavily attacked by this pest, more especially the early ones. About a third of the plants were cut off in the control plot and almost as many in DD. When replaced by new ones, many of the latter were again cut down. The CC plot also lost quite a number, but the AA and BB plots only one plant each. It did not appear to me possible that this difference was due to the presence of radium and I should scarcely have noted it but for the fact that a gentleman who had applied R A F to his lawn in Virginia called to say that his was the only lawn in his neighborhood that had not suffered from cut-worms, some having suffered so greatly as to be nearly destroyed. It will be very desirable to follow up these two cases with others and ascertain whether the R A F is actually responsible for the protection observed.

The relative effects on the upper and lower portions of a sloping plot have not been uniform. Of ten rows of celery so planted, plants in the lower rows are nearly twice as large as those in the upper ones, and the transition is gradual and nearly equable. A possible explanation of this is by assuming that in case of a hard rain, with surface drainage, the emanations in the water in the soil would quickly diffuse through the surface water and be carried downward. In the case of eggplants there is an equal difference, but in favor of those in the upper rows. One might explain this by assuming that the emanations from the upper rows, which escape into the air, would pass over the surface of the ground in the lower rows. Their action upon the aerial tissues is relatively slight. Those from the lower rows would strike the roots of the plants in the upper rows. The explanations are mutually contradictory, but so are the effects observed in the two cases.

In conclusion, it may be stated that the yield of most crops has been increased by the addition of some amount of R A F, the amount differing with different crops. The beneficial effects continue over successive crops, perhaps for many years. The largest amount required by any crop would cost less than the increased market value of such crop of the first year.

Radium is not a plant food. The necessity for fertilizer is but little decreased by its use. The fertility of unused ground will spontaneously increase at a much greater rate when treated by radium.

Subjects worthy of investigation are the effects on yield of fruit trees and vines; the specific effects on individual plant diseases; the relative value of placing the R A F in the rows or hills and of sowing it broadcast; the effects on the decomposition of organic matter in the soil; the influence of the different kinds of soil upon the result; the ultimate effects on the vitality and quality of crops raised from seeds successively produced for some years on radium treated soil; the influence on the medicinal strength of drug plants; the effect on crops not tested in my experiments, as flax, mustard, sweet potatoes, peanuts, cotton, tobacco, sugar cane, pieplant, alfalfa, etc.; specific effects on different flowers.

The results at the Weja (Northfield, O.) farm call for some special consideration. The soil here was of a totally different character from that at Nutley. The basic soil is a stiff clay, forming a deep, heavy, tenacious mud in very wet weather and baking rather hard during a drought. In the lower places this clay is overlaid by and more or less mixed with a large quantity of decayed vegetable matter, forming a black muck in rainy weather and a dry powdery mass during a drought.

Another important difference is that the R A F as well as the fertilizer, was drilled in the rows or deposited in the hills, instead of being sown broadcast as at Nutley.

Finally, the plots were of a large size, in no case smaller than one twentieth of an acre and in some cases including several acres. In each case, the land was so selected that all the plots of one crop were approximately of the same character, and in all other respects the conditions were uniformly maintained for all five plots. Owing to one or more or all of these differences, the increases secured by the use of the R A F were nearly double what they were at Nutley. There is, however, a general uniformity in the relative results on the several plots of any one crop. These results are displayed in the following table:

RESULTS AT THE WEJA FARM.

Variety.	Amount R-A Earth Per Acre.	Per Cent Gain Over Control.
Beans, Black String	25 lbs.	27
Cabbage, Early	50 lbs.	68
Corn, Golden Bantam	100+ lbs.	25
Corn, Country Gentleman	100 lbs.	105
Cucumbers	100 lbs.	55.4
Oats	100 lbs.	50
Peas, Early	100 lbs.	51.7
Peas, Late	100 lbs.	45.2
Potatoes, Early	50 lbs.	60
Pumpkins	100 lbs.	135
Radishes	50 lbs.	21.2
Squash	12½ lbs.	24.6
Tomatoes	100 lbs.	50.6
Field Corn	50 lbs.	19

Altogether, it is fair to assume that the results on this large farm approached more nearly to those to be expected in ordinary agricultural operations than did those at Nutley.

Since the above was placed in type, a correspondent in Mississippi has reported the results of trials with radishes, turnips, beets, lettuce, cabbage, carrots and potatoes as having been entirely negative, the three last being second crops on the same ground. In these trials, the R A F at the rate of about 100 pounds to the acre, was placed in the alternate rows. No fertilizer was employed and the season was one of severe and prolonged drought.

Another, in Florida, reports no effects on string beans, but on potatoes 1.4 per cent increase from 50 pounds to the acre, 4 per cent from 100 pounds and 13.8 per cent from 200 pounds. In this case each of the different amounts was placed upon an isolated plot of 100 square feet.

Eugenics and War

The second Galton Lecture, in memory of Sir Francis Galton, born February 16th, 1822, was delivered on February 16th to the Eugenics Education Society by Prof. J. Arthur Thomson of Aberdeen University, who spoke on eugenics and war. Certainties as to the effect of war on the natural inheritance of the race have not yet been established, but some probable risks are discernible. In ancient times, when fighting was the order of the day, a weaker clan may have been literally extirpated by a stronger, as black rat by brown rat; but nation does not exterminate nation nowadays. In ancient times a battle may have been an effective sifting out of the weaker, less nimble, more cowardly combatants; but it is not so now. For the elimination is either fortuitous or in the wrong direction. The finest bodies of men are chosen for the most hazardous tasks, often involving terrible mortality, and the conspicuously brave are particularly apt to be cut off. In modern warfare the sifting tends to be dysgenic.

In the second place, there is in the making and maintenance of the army, in a nation with voluntary military service, a selection of the more chivalrous, the more virile, the more courageous, the more patriotic, and among these there is a mortality high above that of non-combatants, which means some degree of impoverishment of the race. If the number of combatants was small in comparison with that of the non-combatants, the degree of impoverishment might be slight, but if we have in our British population about 6,250,000 men between eighteen and forty-five, and if we have, as we may well have, a fighting force of three millions, the disproportionate mortality among the combatants is likely to be serious. The eugenic safeguard is in the sound nucleus of "fit" and brave men who remain to keep things going, and in the women (though they again are differentially affected in Belgium and Serbia), but it looks as if this war meant for Britain a disproportionate elimination of those whom we can least afford to lose. Darwin's sentence, in reference to the past, is probably true of the present: "The bravest men, who were always willing to come to the front in war, and who risked their lives for others, would on an average perish in larger numbers than other men."

In the third place, there can be little doubt that the economies and retrenchments after a great war tend to handicap most severely the more highly individuated members of the community. The highly skilled, whose work is not absolutely necessary, will be pinched most; and they are the salt of the race. On the whole, the tendency of modern warfare is dysgenic.

The second subject of discussion was the Darwinian concept of the struggle for existence, in regard to which there is widespread misunderstanding. As Darwin said, the term is used "in a large and metaphorical sense," to include all forms of the clash that occurs when organisms assert themselves in any fashion against environing limitations and difficulties. The reactions may be competitive or non-competitive, self-regarding or other-regarding, with teeth and claws, or with wits and kindness. It is not doubted that one way in which animals answer back to their difficulties and limitations is to intensify internecine competition; it is maintained, however, that another way, common among the finer forms of life, is to increase parental care or to experiment in co-operation. An extraordinarily large proportion of the time and energy of living creatures is devoted to activities which are not to the advantage of the individual, and is an inadequately appreciated part of nature's strategy that the types that survive are not only those that sharpen weapons and thicken armor, but also those in which the individual has been more or less subordinated to the welfare of the race. The improbability of war being the saving grace of human history grows upon us.

The third point in the lecture was that since war, *biologically regarded*, is, in spite of all its nobility, heroism, and skill, a reversion to the most primitive and crude form of the struggle for existence, it involves a serious risk of slipping down the rungs of the ladder of evolution. What sowings of dragons' teeth there must be in the terrible struggle of this war; is it weak to be afraid lest by and by the crop that springs from them may include something worse than armed men?

The discussion then turned to the eugenic position in regard to some practical questions. It is possible that the losses of the war, taken along with the falling birth-rate, may move public sentiment to a stronger disapproval of selfish forms of celibacy and to a stronger encouragement of chivalrous marriages. There is patriotism in dying for our country, perhaps also in marrying for her. In regard to the marriage of recruits, more than eugenic considerations have to be borne in mind, but where adequate provision is secured for the possible widows and children, there seems no reason to place obstacles in the way of the marriage of recruits of suitable age and good record. It is for eugenists to scan critically all proposals hurriedly projected to meet crises of war strain, such as putting children at the disposal of the farmer—a doubly dangerous suggestion. To be resisted also is the natural desire to economise in the higher super-necessaries, such as various forms of art, for this means crippling super-men. One of the results of the war is likely to be a freshened enthusiasm for all-round physical fitness, and it must be granted that all improvements of nurture are eugenic as long as it is clearly recognised that veneering does not make bad wood sound. The British temperament has an inherent dislike of coercion, and schemes of compulsory military training are to be looked on with grave suspicion. There is the risk of insidious Prussianising. For the undeniable privilege of being part of civilised Europe and for the undeniable distinction of having been willing—on this occasion—to do the right thing at all costs, we shall have to pay a long price, and it is to be feared that part of this price will be the shelving of eugenic endeavors and our connivance thereat. It may be, however, that facts will give the lie to our fears, and that the impoverishment of the possible parent-stock of the future will be in some measure counteracted by an enrichment of our social heritage—perhaps even by a nearer approach than we have ever known to goodwill among men.—From *Nature*.

What Everyone Should Know About Cancer*

Suggestions for Avoiding this Very Prevalent Disease

By Joseph C. Bloodgood, M.D.

In the year 1913 in the registered areas of the United States 75,000 people died of cancer. As the registered area only includes about 60 per cent of the population, the number of deaths annually must be much greater than 75,000.

In adults, after the age of forty, cancer is one of the most frequent causes of death. Now that tuberculosis has to a certain extent been controlled, some statisticians claim that cancer is a more frequent cause of death than tuberculosis in people over forty.

Those who know the facts about cancer are of the opinion that if the public can be properly educated in regard to cancer, the annual mortality should be reduced at least one half, and perhaps two thirds.

When the last five years (1908 to 1913) are compared with the previous eighteen, the following signs of improvements are noted: Early cases of cancerous or precancerous inflammations of the lip have increased from 4 to 18 per cent, the inoperable cancers of the lip have decreased from 18 to 8 per cent, the per cent of cures shows an increase from about 60 to 80; the earliest affections of the tongue have increased from 8 to 30 per cent; the inoperable cancers of the tongue have decreased from 18 to 10 per cent; the per cent of cures shows an increase from 21 to 50 per cent. In cancer of the breast inoperable cases have been reduced from 27 to 18 per cent; 5-year cures have increased from 35 to 42 per cent. This means that patients are consulting surgeons in the very early stages instead of waiting until it is too late.

This improvement is due chiefly to a surgical intervention earlier after the first sign of the local disease. Very little improvement can be attributed to better surgical measures.

The chief hope for increasing the number of cures of cancer is early operation. Now, people cannot be treated unless they seek advice. They must be instructed, therefore, when to seek advice. They require information (authentic information) on the earliest signs of conditions which are, or might lead to, cancer.

As a matter of fact, the average individual would never think of seeking medical advice in this earliest stage.

Therefore, the price of protection from cancer is information and education directed to the public and to the profession.

When we have the information as to what may be the first beginnings or warnings of cancer, we should educate ourselves to have fear then, because this fear will induce us to undergo an examination and treatment in such an early stage that the chances of a cure will usually be 100 per cent. Now fear, as a rule, comes too late.

Fortunate is the individual who experiences pain, and severe pain, in the early stages of his trouble, because it urges immediate attention. But pain in the great majority of cases is a late symptom of cancer. If one waits for pain, the probabilities of a cure are greatly reduced.

Cancer never begins in a healthy spot. There may be some dispute as to this statement. But experience in a large number of cases proves that this is absolutely true. In those areas accessible to sight and touch, we are always informed of a defect entirely different in appearance and size from the cancer which later developed in this spot. Now there is always some local trouble which precedes the development of the cancer. This so-called precancerous lesion is the first warning.

The first warnings of cancer do not differ from the warnings of diseases that are not cancer. This explains why to-day and in the past most people come for surgical aid in the late stage of cancer, because when they were first warned, they did not think of cancer, because many individuals similarly warned did not develop cancer. This is true of the precancerous lesions of the skin and mucous membranes, of lumps in the breast, of diseases of bones and joints, of lesions of the uterus, stomach and colon. On the other hand, it is a fortunate state of affairs, because the educated individual, when warned, will know that, in the great majority of cases, the chances are that it does not mean cancer, or that cancer has not yet developed, and this individual will also know that if he secures a proper examination at once to be followed by the appropriate treatment, his chances of a permanent cure will be best even if the trouble should prove to be cancer.

* Reprinted from a bulletin issued by the American Medical Association.

It is important, therefore, to repeat that the first warnings of cancer are not different from the diseases that may later be cancer, or that never develop into cancer; that everyone will be duly warned, and in the great majority of cases that warning will be in plenty of time for protection.

Few people and not many in the profession realize that when the diagnosis is easy the prognosis (outcome) is bad. This is especially true in cancer, and has lead to the terms clinically benign and clinically malignant. In the former, the usual signs of malignancy are absent. Now, if the cancer is recognized at the examination, or at the exploratory operation, and the appropriate operation follows immediately, the probabilities of a cure are best. But in the cases which are clinically malignant, cancer is written on the surface of the body. The same operation may be possible and at the operation it may appear that the disease is equally well eradicated, but the probability of a cure is greatly reduced. The figures in cancer of the breast show this best. Under the microscope in the two groups it is the same cancer. The difference in the results, therefore, depends on early recognition and treatment.

In this propaganda we must inform the people that not only must they heed at once these first warnings and consult a physician, but at the first consultation they must expect and insist on a thorough examination.

In the beginnings of things, especially when there is pain or discomfort, many patients seek the aid of quack remedies. They do not know that medicines which relieves pain does not, as a rule, have any effect on the disease itself. It simply produces a period of freedom from discomfort and by so much delays the best time for treatment. Undoubtedly people can be educated in the treatment of many simple things after they have become thoroughly familiar with the signs and symptoms, but when a new warning appears, something about which there has as yet been no instruction, they should answer it at once by seeing their physician.

Most cancers are curable in the beginning. We may safely say to-day that in the majority of cases surgery has conquered the technic of the operation for the different kinds of cancer in the different localities. The cure of cancer to-day depends on earlier recognition and earlier operation. If one is to have an operation, why not have it in time? If you want it in time, answer the first warnings.

In cancer of the skin and mucous membrane, in over 1,200 cases, there has always been a previous lesion before the development of cancer. These have been pre-existing congenital or acquired tumors, such as moles, warts, or lumps, unhealed wounds, chronic ulcers, areas of skin or mucous membrane, subjected to irritation, and scar or healed wounds. Every patient who has come under treatment with cancer has always told of these beginnings. The interval of time between the onset of the precancerous lesion and the beginning of a local growth which would suggest cancer, has varied between months and years. We can be absolutely certain of the local precancerous lesion, but we cannot predict whether, or when, cancer may develop. We know that if we excise such a lesion, we have removed at least one, and perhaps the only one, visible spot on the body in which cancer may develop.

In proper hands, there is no danger and no disfigurement in the complete excision of such precancerous lesions. In some cases the cause of the irritation can be removed, such as a ragged tooth which irritates the tongue and mucous membrane of the mouth; or the habit of smoking and chewing tobacco in cases of smokers' burn. In some cases, the little ulcer or wound can be healed by simple cleanliness, or by some mild dressing. But everyone should know that any irritating treatment of the little precancerous lesion increases the danger of cancer, and if cancer has already developed increases its local growth. Everyone should know that any incomplete treatment which does not remove every cell of the lesion is more dangerous than delayed proper treatment.

Among the 200 cases of lesions of the lip recorded in the Surgical Pathological Laboratory of the Johns Hopkins Hospital the following interesting facts have been ascertained:

Due to the local education propaganda the per cent of benign cancerous lesions has increased in the past 5 years from 4 to 18. The late and inoperable cases of cancer of the lip have decreased from 18 to 8 per cent. The per cent of cures in all cases in which the primary lesion on the lip has not been previously treated or irritated, has been 75, while if the lesion on the lip had received any previous treatment, the same operative methods have yielded but 33 per cent of cures.

The failure to cure all cases has been due largely to delay. When we have removed the cancer of the lip and the glands in the neck, and the glands showed no evidence of cancer, there have been 95 per cent of cures, while if the glands did show cancer, the cured were but 50 per cent. Here the surgery has been the same. The involvement of the glands depends on delay. It is possible for the glands to be involved one month after the beginning of the lesion. As a rule they seldom show involvement in lesions present three months or less. The best time to cut out a lesion on the lower lip is within one month after its onset. There is no reason to wait longer. If the little sore has not disappeared then, have it cut out. The per cent of cures in such cases has been 100, and in this group is one cancer with infection of the glands. The per cent of cures in the three-months cases is 96; in later cases about 60; in all cases, as stated before, 75.

The other cause for failure was incomplete surgery, resulting in failure to remove the glands of the neck.

Everyone of us will be warned in time in lesions of the lower lip. No individual so educated should die of cancer of the lip. The protection is the early removal of a V-shaped piece including the unhealed lesion.

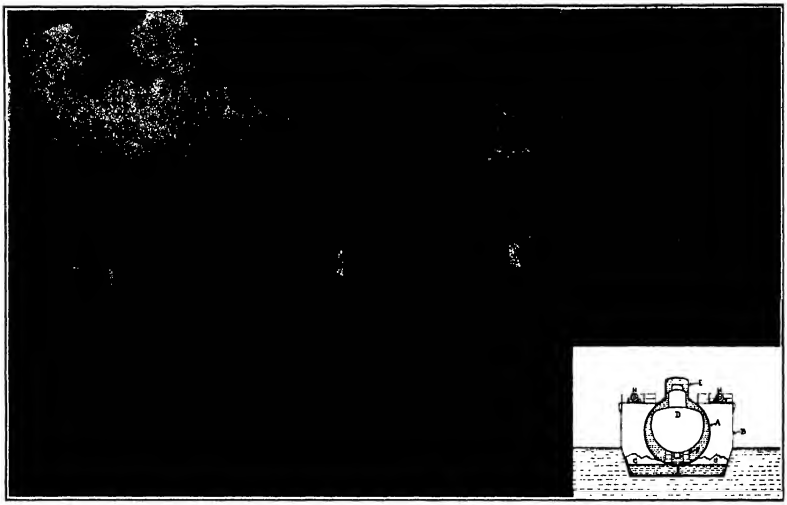
What has just been stated in regard to the lip, has been found to be also true of lesions of the tongue. The danger of the delay seems much greater in lesions of the tongue than in similar lesions of the lip. This danger is not due so much to the possible or probable involvement of the glands of the neck, but to the infection of the muscles in the floor of the mouth. This is responsible for the local recurrences and failures to cure, even after the most extensive removal of tongue and glands. When the floor of the mouth is removed without removing the lower jaw the danger of pneumonia and infection is great and the mortality has been high. The removal of the lower jaw is mutilating. The mutilation is greatest when the center of the jaw must be removed. The evidence is based on a careful study of over one hundred cases. The educational propaganda has increased the benign precancerous lesions from 8 to 30 per cent and decreased the inoperable cancers of the tongue from 18 to 10 per cent; the probability of a cure has jumped from 21 to 50 per cent. This improvement, however, is not all due to earlier intervention. There has also been great improvement in the surgery.

The present condition of cancer of the tongue in relation to early diagnosis and treatment is deplorable. The public and profession are not educated as to the dangers of any form of lesion on the tongue and mucous membrane on the floor of the mouth. In the majority of cases a diagnosis of syphilis is made and time thus lost. The majority of cases of cancer of the tongue came to the surgeon too late. I am confident that in the majority of clinics 20 per cent or more are inoperable. In this late stage the surgery has been incomplete in that the floor of the mouth has not been removed with the lower jaw.

When any sore exists on the tongue or in the mouth, the use of tobacco should be at once discontinued. The teeth should be put in order, a mouth-wash of bicarbonate of soda employed. The blood should be taken for a Wassermann reaction. If this is positive, salvarsan should be administered. If the sore does not heal and completely disappear within two weeks (there is nothing to be gained by further delay), it should be cut out with a good margin with the electric cautery, preserving the center of the sore for microscopic study. This operation can be done under local anesthesia. It leaves no defect. If this is done within two or three weeks of the onset of the lesion, the operation is sufficient, even if the microscope shows cancer.

Further delay increases the chances of the development of cancer. If this develops, the operation necessary to give the patient the best chance of a permanent cure must be much more extensive and the floor of the mouth must be removed with a piece of the lower jaw.

The last word which scientific medicine has to say in cancer is: Go to a competent surgeon *at once*, as soon as any lump or sore appears that does not go away in a few weeks. The earlier you have proper treatment, the less the danger, the less the pain, the less the disfigurement, the less the expense. A trivial operation may prevent a serious one and may save your life.



Length over all... 235 feet
Length available inside 213 feet
Internal diameter of pressure tube 23 feet

Displacement loaded 925 tons
Displacement light 500 tons

A, pressure tube; *B*, caissons; *C*, water ballast; *D*, submarine; *E*, pressure hood for conning tower; *F*, keel blocks; *H*, electric winches.

Italian salvage vessel and testing dock for submarines.

Salving Sunken Submarines

Provision Made by Foreign Countries Anticipating Accidents

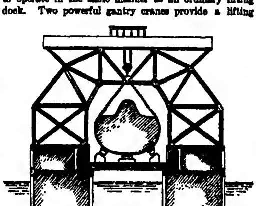
THE sad disaster that has overtaken the submarine "F-4" at Honolulu reminds us forcibly that this type of craft is peculiarly liable to a variety of mishaps that are unknown to ordinary vessels, as well as the ordinary dangers of the sea; and coming as it does while we are reading of the marvelous performances of the German submarines in the strenuous work of actual war it is suggestive of how much good fortune has to do with a successful raid.

There is another and more serious side to this matter. Fatal accidents to submarines in times of peace have been not at all uncommon for there have been between twenty and thirty such accidents, resulting in the loss of in the neighborhood of three hundred lives, fortunately all abroad; but this is no excuse for disregarding the warning so plainly given, for while several foreign countries have built vessels specially designed for the quick salvage of submarines in trouble below the surface, our Government, in its anxiety to cater to sentimental "peace" advocates, has permitted our brave officers and men to continue their preparations for public protection without taking the slightest action to make provision for their safety.

It is not pleasant to think that men may be carried to the bottom in underwater boats under circumstances which make it possible for them to survive in their confinement for many long hours and yet, in the end, die because the salvage equipment is inadequate to cope with their relatively speedy raising. This has happened abroad, upon several occasions, under harrowing conditions, and it may occur here again if some provision is not promptly made to prepare for just such an emergency. It is not fair to the men that take the risks necessarily involved in service aboard submarines to hesitate longer in building the required salvage apparatus.

There are some kinds of accidents which may send a submarine to her doom and against which no foresight can provide; but, again, there are other circumstances which may cause a submarine to sink and which may be either entirely eliminated or largely minimized by provision. To a large extent, this anticipation of accident lies in making the submarine strong enough to resist the stresses of deep submergence and in equipping the boat with pumps and other tried means for the expulsion of water ballast or for the neutralizing of reasonable leaks at those depths. It will be asserted authoritatively that we are now taking these very steps, and it is a matter of common knowledge that our submarines, before their final acceptance by the Government, are actually subjected to a submergence test which requires the boats to be sunk, without anyone aboard, to a depth of 200 feet. The inspiration for these trials was an accident to one of our own submarines of the first group built, which, when 125 feet down—she was carried there by leaky valves—leaked so menacingly that she was brought by her crew to the surface again only through the desperate working of a single hand-pump. It was a very close shave for her people, but it did not teach the Government any salutary lesson.

Germany was the first country to recognize the dangers and requirements of sub-surface navigation, and, anticipating the very kind of accident that has befallen our "F-4," as long ago as 1910 built special vessels for the salvage of submarines, and also arranged it in such a way that it could be used as a floating dry dock for repair work on these craft. This vessel is a powerful self-propelled craft 230 feet long with a double hull arranged to operate in the same manner as an ordinary lifting dock. Two powerful gantry cranes provide a lifting power capable of handling a weight of 500 tons, and with its tackles hooked to chain slings, or to strong ring bolts built into the hull of a submarine, any submarine boat can be drawn up at a speed of about 80 feet a minute. Inside the pontoon hulls, and at a suitable height above the waterline, shelves are provided which will support a removable dock floor that enables work to be done on a submarine after it has been lifted clear of the water. This mobile dry dock has undoubtedly been of great value during the present hostilities.



Cross-section of the German salvage ship, showing a submarine lifted by the gantry crane and placed upon the removable floor of the dock.

Italy has also provided a special craft as an auxiliary to submarine work, but it is rather more in the nature of a testing device than as a rescue apparatus, although it is better adapted for this work than the ordinary marine derrick, and it can also be utilized as a floating repair dock.

As will be seen in one of the accompanying illustrations the "Laurenti," which is the name of the Italian device, consists fundamentally of a long steel tube *A*, capable of withstanding high pressures exerted from within, into which a submarine *D* can be floated and secured, after which the entrance is hermetically sealed. In our picture, the gateway is shown on the left sealed by the convex caisson. The pressure tube is supported by ballast tanks *B*, which can be filled with water ballast *C* or exhausted as occasion requires. The dock has its own power plant and its own pumping equipment. A removable hood *E* provides a housing for the conning tower. The tube is supplied with keel blocks *F*, and electrically-driven capstans *H H*. When the submarine is held within the dock and surrounded by water filling the tube, as shown by the small diagram, pressure is exerted upon the enveloping water by a suitable steam pump, and this pressure can be raised greatly in excess of the hydrostatic pressure to which a submarine would be likely to be subjected voluntarily. Observers remain in the submarine while undergoing this pressure trial, and telephonic facilities keep them in touch with those in charge of the dock and the pumping plant. In this way the inspection can be carried on deliberately and exhaustively, and all of the operative mechanisms can be put in motion and tried under physical conditions truly reproducing the circumstances of actual deep submergence. There is no hazard involved, and the whole operation can be conducted right at the yard.

The German salvage vessel "Vulkan." Can lift 500 tons 25 meters in an hour.

Bow view of French salvage vessel for submarines.

Our illustration also shows how the Laurenti dock can be used as a salvage apparatus. In this manner a sunken submarine can be raised and carried into port or borne to shallow water, where she can be opened and entered if such an operation be desirable. In addition to being a testing dock, the Laurenti submarine auxiliary can also be employed as an ordinary floating dock for under-water boats, and in our picture the plating is removed amidships to show a submarine resting inside.

France also long ago provided for the necessities of its submarine flotilla by building a vessel very similar in general design to the German ship, but of greater capacity and about double the lifting power of the latter, and an excellent idea of its construction can be had from our illustrations.

The permanence of the submarine, both as an instrument of offense and defense, has been definitely settled the last few months, and, reading between the lines of published reports of the doings of the German craft, there is not the slightest doubt but that auxiliary vessels of the general character of those here described are absolutely essential to the successful prosecution of submarine enterprises; and with these facts so plainly demonstrated, and made emphatic by our present disaster, our Government should lose no time in taking steps in this direction, for at present the United States possesses absolutely nothing of this description.

The Use and Care of a Watch*

The importance of the careful handling of a fine watch, of regularity in winding it, and of frequent checking of its correction with some source of accurate time in order to obtain the best results is so well known as scarcely to need emphasis. However, with the thought of calling the reader's attention to some important precautions heretofore overlooked, the following suggestions on the handling, winding, and carrying of a watch are included here, together with some additional information on the sources of accurate time measurement with which one may frequently compare his watch.

It is well known that a fall or severe jar is liable to injure the mechanism, especially in the bending of a pivot or the breaking of a jewel. It is, perhaps, not so well known that the mere fall of a watch to the end of its chain, or the jar it may receive when the article of clothing containing the watch is thrown down or dropped may cause as serious an injury to some part of the movement. Even the sudden motions or jar of jumping off or on a car may injure it seriously. Because of the small size of the pivots necessary in accurate watches all sudden motions of the watch, even when in the hand, should be avoided.

Likewise care should be taken to keep the watch from being magnetized by proximity to electrical apparatus, although the trouble from this cause is being reduced by the present type of construction of dynamos and motors.

Unless the watch has a thoroughly dust-proof case care should be taken to keep the pocket free from dirt and lint, and it is desirable to have a watch pocket of such material that there will be as little accumulation of lint in the pocket as possible. The watchcase should be opened as seldom as possible and only in places where there is little chance of dust gathering on the movement while it is exposed. A broken watch crystal should be replaced promptly, even if the watch has a hunting case, intended to prevent dirt getting into the mechanism.

The importance of the regular winding of a watch will be quickly realized when one sees the isochronism curve of a given watch. Even the delay of an hour in the time of winding may cause considerable variation in the rate in some instances. Often it will materially improve the uniformity of rate of a watch throughout the 24 hours to wind the watch twice a day, but it is desirable that this plan should not be followed unless it is carried out every day, as a watch having comparatively poor adjustment for isochronism would exhibit larger variations of rate when semi-daily windings are occasionally omitted than if it were wound only once a day. Such semi-daily winding should be done as regularly as the daily winding, and the practice of winding up the watch a little at a time, often absent-mindedly, whenever one takes it from his pocket, is not productive of uniformity of rate. The winding should not be done jerkily but steadily and not too rapidly, and its conclusion should be approached carefully to avoid injury to the spring or winding mechanism.

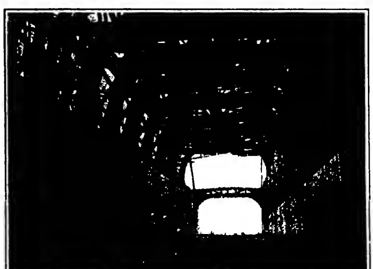
If one winds the watch only once a day, it is generally regarded as slightly better to wind it in the morning than at night, as the large variations of the balance under the tight spring will perhaps give more uniform results with the movements and jar of the watch during the day than if the balance wheel were subject to the lesser tension 12 hours after winding. The difference is, however, not so important as the *regular* winding of the watch, and if circumstances are such that one is more apt to forget to wind it in the morning than in the evening, the latter time of winding should be adopted. If one has an opportunity to compare his watch daily at a certain time with some source of standard time, as with the time sent out by telegraph or by radio (wireless) signals or the dropping of a time ball, or by the regular comparison with some accurate clock as one daily passes a jeweler's store, for instance, it would be well to establish the habit of winding the watch at that time, as it is better to have such daily comparisons made at the time the watch is wound, and more regular winding will usually ensue.

The pocket in which one carries his watch, the size of the pocket, and the kind of watch chain or fob used have a more important effect on the uniformity of a watch's rate than is generally realized. The temperature of the watch in different pockets will vary considerably and the amount of motion and jar to which the watch would be subject would differ. For instance, a watch carried in the upper coat pocket would generally be at a lower temperature and would be more frequently disturbed, as well as being held in various positions more irregularly, than in other pockets. In a large pocket the watch is apt to turn to the right or left by various amounts, giving irregular rates unless one adopts some method to hold it upright. Perhaps the best method to prevent a watch turning in this way (other than actually pinning it in place) is to keep the watch in a chamois or kid watch bag, such as may be obtained from jewelers in correct size to fit one's watch. The watch cannot turn in this if of the proper size, and the friction of the bag in the pocket prevents its turning. The bag also protects the watch and keeps it cleaner. Most watch chains and many watch fobs are not effective in holding the watch upright. A fob of the type which hangs over the top of the pocket sometimes holds the watch upright quite well, but with such a fob one is somewhat more likely to drop the watch.

At night, or when the watch is not in use, it is desirable to leave the watch in the same position as during the day, and preferably in some place where it will not be subject to any great temperature change. If it is desirable to leave the watch in a horizontal position during the night for the sake of compensating any considerable gaining or losing of the watch in the pendant-up position during the day, the same precaution to avoid marked temperature changes should be observed, and the regularity with which such a change of position is carried out may be as important as regularity of winding.

* Circular No. 51, Bureau of Standards.

Stern of French salvage vessel, showing catamaran arrangement of the two hulls.



View between the hulls of the French salvage vessel.
Displacement, 2,300 tons; length, 322 feet. Can lift 1,000 tons from a depth of 120 feet.

A Record of Achievement—II*

The Contribution of the Chemist to the Industrial Development of the United States

By Bernhard C. Hesse

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2048, Page 211, April 3rd, 1915

THE law makers of the United States knew that coal-tar dyes were made almost wholly in Germany; they knew that those dyes were essential to the ordinary growth and conduct of enterprises in this country, not themselves chemical enterprises but which produced large values of goods annually and employed many people; they knew that attempts had been made for over thirty years to produce those dyes in this country, and they knew that they had persistently and deliberately declined to bring about economic conditions which those who were in position to know told them were essential to the establishment of an independent coal-tar industry in this country; they knew that whatever coal-tar dyes were produced in the United States were produced mere by assembling dye-parts which they knew were imported almost wholly from Germany and which they knew could not be profitably made in the United States; finally they knew that if for any reason whatever these dyes could not be obtained from Germany the production of large values of goods and the employment of many people in this country would be interfered with, and very likely seriously interfered with.

However, hardly had the European war broken out than our daily press, well knowing what our law makers had deliberately and knowingly done, covered the American chemist and the American chemical manufacturer with an avalanche of harsh and unjust criticism for not doing that which our law makers knowingly and persistently had made impossible.

Broadly considered, the criticisms of the press may be grouped as follows:

I. The present shortage of dyes and inaccessibility of German producers to the American market offers an unusual opportunity for the manufacture of coal-tar dyes in this country.

II. The chemical manufacturers of this country should make those coal-tar dyes.

NO SHORTAGE OF DYES.

With regard to the first of these it is very pertinent to ask: "*Is there a shortage?*" An open and fair-minded perusal of the textile trade papers, and of the textile sections of daily trade papers from about the middle of August, 1914, to date, leaves the question as to an actual shortage very much open to doubt, with the chances for a negative answer very favorable.

It is only reasonable to believe that such perusal is very likely to result in the following summary of the situation: At the outbreak of the war our cotton mills were loaded up with cotton that cost them from 13 to 15 cents per pound; shortly after the outbreak of the war the price of cotton dropped until it soon reached a level of about 6 cents; *buyers* of colored cottons insisted upon prices for the manufactured goods based upon the then current prices of cotton; *sellers* of cotton goods insisted that the shortage of dyes was sufficient warrant for holding out for prices for colored cotton higher than the current prices of cotton would seem to justify; the buyers would not buy and the sellers would not reduce the prices. In the meantime dyestuff shipments which were curtailed in some of the months, increased, and for the year of 1914 the receipts of dyestuffs, i. e., alizarin, etc., dyes, coal-tar dyes, indigo and anilin salts are $633,616 under 1913; that is, the totals for 1913 were $10,065,012, and for 1914, $9,431,396; in other words, 1914 was 93.4 per cent of 1913. In 1912 the corresponding total was $10,386,703; i. e., 1913 was only 96.9 per cent of 1912 or $321,691 short of 1912. No one complained in 1913 that this shortage as against 1912 was due to the American chemist. The answer, therefore, is that there was not any serious shortage of dyestuffs. With that answer also falls the principal condition upon which the press of this country based its insistent demand for immediate dyestuff manufacture in this country.

In this connection it is of interest to note what Mr. William G. Garcelon, secretary of the Arkwright Club of Boston, which includes the treasurers' of cotton mills, said on January 13th, 1915, to the Committee on Patents, House of Representatives:

"I presume there are mills all over the country who are suffering from a shortage of dyestuffs. The reports that I have are that the dyestuff men are struggling very hard to look after their customers, and they are succeeding, I think, for the most part. The difficulty perhaps goes deeper than the dyestuff question, because the mills cannot sell their goods. But if they could sell their goods here in this country or anywhere else they might buy more dyestuffs than they do.

"There is another problem, of course, that interests them, and that is the cotton market, a year's supply of cotton having been bought at somewhere between 13 and 15 cents, and on account of the war the price of cotton dropping to 6 and 7 cents, and the mills finding themselves stocked with high priced cotton and the buyers demanding goods at the basis of 6 cent cotton. It is not, of course, a profitable situation for the mill people. The mills of New England, with exceptions where specialties are involved or where there are large contracts ahead, are not busy. Most of them are running on four and five days' time and curtailing at every possible opportunity, because of business conditions. . . . It (the Paige Bill) has been discussed, but if you had been in the manufacturing of cotton goods during the last three or four months and had been trying to work at the cotton end of it, and trying to work at the dyestuff end of it, and trying to work out your practice based on cotton which was bought at 15 cents, and which you could now buy at 6 cents, and had all the troubles—I will say this, that it would probably have been much better for the cotton mills of New England if cotton had remained at 12 or 13 or 14 or 15 cents, because we bought our cotton at 13 to 15 cents, and now the purchasers are trying to buy our goods on a basis of 6-cent cotton, and we are in a hole because of that."

THE UNITED STATES MUST BE INDEPENDENT.

Collaterally to this supposed dyestuff shortage our press urged that American industries should be independent of Europe for such vital materials as dyestuffs. Probably on some sort of reasoning, such as that employed by Lord Moulton, viz., that one dollar's worth of dyestuffs is necessary to the production of $100 worth of manufactured product. Granting that dyestuffs are really so important and that such an important constituent of a manufactured product should be manufactured in this country, brings us up to a discussion of the second question.

The dividends declared and paid by the German dyestuff manufactories in 1912 are in the neighborhood of 10 per cent on the annual turn-over. For the purpose of discussion, let us assume it is 25 per cent, and let us assume that the man who makes this $100's worth of manufactured product makes 10 per cent or $10 profit on that. The textile maker, therefore, makes $10 where the dyestuff maker can make 25 cents, or more likely 10 cents if he can manufacture as cheaply as can the German. The American dyestuff and chemical manufacturer is not and has never been attracted by that possible 25 cents profit. The textile maker is spending that dollar anyhow to somebody; the American dyestuff and chemical maker does not care to make that dollar's worth of commodity. It is of no consequence to him in his business; he is making a living some other way, but the textile maker says it is a matter of life and death to him to get those dyestuffs.

THE DYE USERS MUST MAKE THE DYES.

An obvious question at this point is that if the dyes are so vital to the textile makers, and the American dye makers will not make them, why do not the textile makers invest their money in a dyestuff plant and charge up any losses that they may sustain thereby as insurance premium to insure the sale of their goods and the profit therefrom resulting, just as they make their own soap, if need be? There is no ethical nor professional reason against their so investing their money.

Even if the textile maker, under those conditions, would just break even, he would still be a gainer; but the American dyestuff and chemical maker would, under those conditions, be a loser, because he would be unable to return dividends to his stockholders, who have the very unfortunate habit of insisting upon dividends. If it cost the textile maker $1.50 to make a dollar's worth of dye, he would be out 50 cents; that is, he would have paid a 5 cent insurance premium to make sure of a 95 cent profit; if the dyestuff and chemical maker were obliged to sell a thing that cost him $1.50 at $1, the sheriff would very soon have possession of his property.

Granting, therefore, that the stability of our textile and allied industries demands that these materials be produced in this country, it also follows that the financial burden and risk connected with the manufacture of the dyes should fall upon them. To this responsibility I have yet to see from the dye users of this country any adequate or sufficient answer.

If it be the part of wisdom for textile makers not to enter upon the manufacture of dyestuffs in this country, even though dyestuffs are a matter of life and death for them industrially, then where is the wisdom in the chemical manufacturers of this country, who are making satisfactory money in other fields, risking millions of dollars of real money and years of effort and labor in an attempt to make 25 per cent at the very outside, when it would be money in the pockets of the textile makers to invest their capital in the very same venture and be ahead of the game, even if they lose 50 cents on every dollar's worth of dye produced?

I have no doubt in my own mind that the stockholders and the bondholders in our various chemical enterprises would resist any such venture on the part of their respective properties.

Throughout, since the beginning of the war, it seems that the sellers of colored cotton goods have been indulging in the cry of "wolf" many times more than once too often, and the buyers of cotton goods have not believed them; if the buyers of cotton goods, knowing the sellers of cotton goods better than the manufacturers of chemicals do, will not believe those sellers, what reason have the chemical manufacturers to believe the sellers, or, upon representations of those sellers alone, to invest huge sums of money and vast effort in an attempt to help the sellers?

PATRIOTISM AND BUSINESS.

One answer that seems to be uppermost is that the chemical manufacturers should have a sufficient sense of patriotism to lose their money, and the money of their stockholders, in order to help out the textile makers. On this point the *Journal of Commerce* of October 5th, 1914, says: "There are some merchants who think motives of patriotism should prevent large purchases of foreign goods at this time, but there is not as much patriotism in business as one liked to hope for, and the cold fact of the situation is that constant appeals are made by the holders of foreign merchandise for any opportunity to unload here."

If patriotism will not induce buyers of cotton goods or sellers of cotton goods to pay more for goods made in the United States than for those made elsewhere, then why should patriotism cause the chemical manufacturers of this country to go ahead deliberately with a project in which they are sure to lose money?

WHY AMERICAN DYE-MAKERS CANNOT COMPETE.

But the answer to that is, "Sure to lose money, why?" and the answer to that question is a very long story, but it can be summed up as follows: The total world's consumption of coal-tar dyes of all kinds, the year round, and the world over is considerably below $100,000,000; ever since 1879, chemical and dyestuff manufacturers in this country have been attempting to get that business, or a portion of it, away from Germany; not only that, but the chemical manufacturers in Austria, Belgium, France, Great Britain, Italy, Russia, and Switzerland have been engaged in the same effort, and all of them have failed; there is no real reason to look for glittering and immediate success now.

At the end of the year 1912 the world owed Germany $51,545,328 for dyes. Switzerland was second with a credit against the world of $3,794,898. Great Britain was the home of the coal-tar industry, but the Germans took it. At the end of 1912 Great Britain owed Germany, $6,275,775, for this class of goods.

For the fiscal year ending June 30th, 1912, German dyestuff factories declared and paid dividends of 21.74 per cent on their capital stock; for the fiscal year ending June 30th, 1913, they declared and paid dividends of 24.96 per cent on their capital stock; in both years the dyestuff makers' dividends were fully 10 points ahead of the nearest income-producing division of the entire German chemical industry. In other words, the German dye industry is getting stronger all the time, not only relatively, but actually as well, for her competitors are becoming more and more dependent upon her; this is shown by the fact that Great Britain and France were hit more quickly and more acutely by the failure to obtain dyestuffs and dyestuff materials from Germany on account of the war, than was this country, in spite of the fact that both countries have branch factories of German dyestuff works within their borders. It must also be remembered that in the early history of the coal-tar dye business, France was an important factor, not only in the invention of dyes, but in their manufacture, but it, too, has had to yield to Germany.

THE [illegible]

Now the American chemical manufacturer is urged to transplant to this country as much of the German coal-tar dye industry as is needed to satisfy the wants of this country. To transplant this whole of it means that the American chemist must learn how to produce on a

* An address before the American Chemical Society at its fiftieth meeting, New Orleans, March 31st-April 3rd, 1915. From *The Journal of Industrial and Engineering Chemistry*.

commercial scale, at low prices and in high quality, over 1,200 different chemical products, each distinct from the other, each calling for separate manufacture and close and careful supervision of each step. The textile makers could make the problem a great deal easier for the American chemical manufacturer by making up a statement for the chemical nature of all dyes that they use, the amount used annually of each, and the average prices at which they have been purchasing them. Should it then turn out that the American textile makers could be satisfied with, say 400 out of the 900 dyes, it might very well be that 200 of the 300 intermediate products would be sufficient, and that would reduce the difficulty of the dye manufacturers' problem by 50 per cent. This is not an unreasonable expectation since seven colors have been able to do substantially all the tinctorial work of the 80 different colors used in food coloring prior to their prohibition by our Federal and State Governments. The textile makers decline absolutely to co-operate even to this slight extent.

Surely compared with the demand on the part of the textile makers that the chemical manufacturers invest not less than $5,000,000 and spend a year or two, or even more, in making the 900 different dyes and the required intermediates, the request on the behalf of chemical makers that the dye users furnish some dependable statement as to the actual consumption, both as to kind and amount, and the prices thereof, is a very, very vanishing quantity. The textile makers and other dyestuff users could prepare such a list at a total cost to them of less than $1,000. If the users of dyestuffs are so reluctant about this small expenditure of money and trouble in order to simplify the dye maker's problem by over 50 per cent, representing millions of dollars of real money, the conclusion does not seem to be wholly unjustified that these users of dyestuffs have cried out long before they were even hurt, and that the extent to which they are hurt is not worth $1,000, for the purpose of ascertaining how conditions can be remedied. It is difficult, for me, at any rate, to believe that since the users of dyestuffs in this country will not go to that slight expense, they are very seriously hurt, if they are hurt at all.

Now the public at large has a right to know what it would mean to them to have $10,000,000 worth of dyestuffs produced in this country; roughly it would cost over $5,000,000 of capital and would not, at the very outside, employ to exceed 7,000 people all told, in all divisions of manufacture, sale and distribution of the dyes and the necessary chemicals therefor, and would result in a diminution of our import business by only 0.4 per cent.

I say in all seriousness that this agitation on the part of our press, and this public clamoring that the chemical makers of this country should at once make coal-tar dyes in this country, is very much of a tempest in a tea-pot, and I believe that the presentation just given, is ample justification for anyone's taking the position of "Doubting Thomas." I, at any rate, have come to the conclusion that if coal-tar dyestuffs *must* be made in this country, the users of the coal-tar dyestuffs are the ones who should foot the bill for the venture; they should go out and get the money, and they should stand the losses that are bound to result, since they are in a position to absorb those losses without substantial harm to themselves. Failing that, the public at large must foot the bill.

The remedy that some of these newspapers and other equally ill-informed persons suggest is to alter the policy of our patent laws by introducing requirements for compulsory working. That is, by thus radically altering our policy, we are at once going to get a coal-tar dye industry.

THE BRITISH WORKING CLAUSE.

France, in the early days of the coal-tar dye industry, was an important factor in the invention and in the manufacture of dyes; the same with Great Britain; France has always had a drastic working clause; in 1907, the British working clause was brought about at the insistent agitation of dyestuff makers of Great Britain, and they promised, in effect, to the British public that if that working clause were enacted into statute, an independent British coal-tar dye industry would spring up at once. After the law had been in operation six years and a half and Great Britain could no longer deal with Germany, what was the result? Was Great Britain able to supply its own needs of coal-tar dyes? Certainly not. Was France? Certainly not. Now, since neither of these countries was able to supply its dyestuff needs, when it could no longer trade with Germany, was the working clause the cause of that condition? If not, what was? Certainly the working clause did not prevent that condition from arising. If the British working clause, the last, and presumably the best of the fifty-six measures now in force attempting compulsory working, absolutely and utterly failed to produce in six and a half years a coal-tar dye industry, when it had at that time five coal-tar dye factories of its own—each of them at one time or another making some of their own intermediate products and some of them at times even exporting to Germany—if those five British dye works *plus* the new British working clause could not produce the $6,000,000 worth of dyes a year that Great Britain imported in 1912, and make themselves independent of Germany, on what grounds and by what course of reasoning has anybody the right to assume that if we were to put the British working clause bodily on our statute-book, we would create a large coal-tar dye industry, at once, or within *any reasonable* time?

In a paper entitled "Compulsory Working of Patents," written by Oliver Imray and Hugh Fletcher Moulton, both of London, and read before the International Association for the Protection of Industrial Property at its convention in London in June, 1912, they sum up the effect of the British working clause as follows: "The results attained are, therefore, infinitesimally small compared with the large number of existing patents (100,000) even after deducting from this number those patents which may be considered of minor importance, and this in itself is an absolute proof of what a small call there was for this very serious and drastic alteration of the law, an alteration practically admitted by all countries from many years actual experience to be a mistake."

At the meeting of the Imperial Industries Club of Great Britain, April 1st, 1914, the compulsory working of patents was discussed. No one speaking in favor of the 1907 British Act named any specific cases of any new industries being brought to Great Britain thereby. Those speaking against the Act referred to case after case where foreigners revoked the British patents and then dumped foreign-made goods on the British market. Lord Moulton said of this British Act: "It is no use arguing about legislation of that kind. It is self-condemned."

Those who have spoken favorably of this British Act with but one or two exceptions have colored their statements; for example, one new plant was represented as employing 1,600 people—it employed 37; another represented at 600 employees, employed 60. There are no official figures as to the real effect of this Act; the only figures are those of real estate agents having land and factories for sale; under those circumstances their fall from truth is understandable, but it does not heighten their credibility.

While the debate was on as to this British working clause the rosiest predictions were made, and I remember distinctly that it was promised that $500,000,000 of new capital would be brought into Great Britain on account of this working clause, and that hundreds of thousands of British would receive fresh employment.

Shortly after the enactment of the British working clause there was a considerable scramble among non-British corporations for opportunities to work in England, and that was looked upon as a great confirmation of the wonderful efficiency of that particular Act.

After two years of full operation, and under date of March 23rd, 1911, the London *Times* says: "Some fifty firms have commenced or are about to commence work under the Act, and the new factories involved a total outlay of some $4,000,000. It is hoped that employment will in this connection be found for 7,000 additional men, and that the wages paid to them will total something like $4,000 per week. Among the new industries are metallic filament, electric lamps, kinematograph films, aniline dyes, mercerized cotton, foods and medicines, oxygen, clay glaze. The foreign firms principally represented are German and American." That is, $4,000,000 came in instead of $500,000,000. For fifty firms that makes an average outlay of $80,000 per firm; this is probably four times the truth, at that. Under date of September 26th, 1914, the *Textile Manufacturers Journal* quotes as follows, on page 6, from the *Textile Mercury* of Manchester, England: "*Openings for New Industries*—A few years ago everyone was full of hope of the foundation of new industries in our midst. The occasion was the passing of the Patents Act of 1907, which, for a while, appeared to threaten the validity of foreign-held British patents. Municipalities, dock, railway and estate companies saw what they took to be an opportunity, and they went about to meet it. They issued books and advertisements in furtherance of the claims of their situations in order to catch the eye of capitalists who might entertain the idea of opening English works. For reasons into which it is unnecessary to enter, the result from these efforts was somewhat disappointing. The act did not lead to the establishment of any large number of new factories on British ground, but the facts that the anticipations existed and efforts were made deserve to be remembered at the present." Whatever the cause, the fact is that England to-day cannot make and does not make her own supply of dyestuffs.

Furthermore, it must be remembered that on July 13th, 1832, the President of the United States approved an Act compelling all foreigners to work their patents in the United States under penalty of automatic cancellation. That Act was repealed July 4th, 1836; it died at the tender age of three years, eleven months, and twenty-two days. If it was bad policy for us then, and experience proved it to be, why should it be good policy for us in 1915 to try the same thing over again? It has not worked in any of the fifty-six countries that have tried it? Why should it be successful after so many failures under present conditions, and why should it be successful when the old conditions, under which it invariably failed, returned?

Another thing that must not be lost sight of is that when we put such an Act upon our statute books we expose ourselves to retaliatory measures, and retaliation may take place just as Germany and France retaliated upon Great Britain for the working clause of 1907.

From the London *Times* of March 23rd, 1911, just quoted, it appears that Germany was not the only country hit, but that we suffered with it.

The transplantation of the coal-tar dye industry to the United States is not a question of patent protection; it is nothing but an economic question, a plain matter of dollars and cents; those products can be made in this country if persons will buy those products at a fair margin of profit over the cost of domestic production, and since we know in advance that the cost of production there will be above cost of production elsewhere, plus any prevailing import duty, why should we go to the costly venture of spending millions of dollars to prove the obvious?

As a matter of fact, the whole world's coal-tar dye consumption is about enough to make a decent sized business for one country. Ordinarily it is best to do the world's work where it can be done best and to transport the products from their place of manufacture to their place of consumption. If it be necessary for other reasons that these products should be made elsewhere under conditions economically less favorable, then those who want those products made at such economically unfavorable place should bear the burden, but that is precisely what the dye users do not want to do; they want someone else to foot the bill.

The textile makers say that if they do not get those dyes, 2,000,000 people in this country will be thrown out of work, and in order to prevent that, the chemical manufacturers of this country must go down into their pockets for millions of dollars. Now, who brought those 2,000,000 people into the textile business? Who has the moral responsibility of keeping those 2,000,000 people employed? Is it too much to ask the textile maker to give up, say 5 per cent of his profits to keep his word and live up to his moral obligations, or should the chemists of this country furnish millions of dollars to enable the textile makers to keep their word with the making of which the chemical manufacturer is in no wise concerned? Is it patriotic to decline to give up 5 per cent of your profit in order to keep 2,000,000 people at work, for which 2,000,000 people you are morally, directly responsible? Is it unpatriotic to decline to furnish millions of dollars to aid in the keeping of a promise with which you had nothing whatever to do, and from whose keeping you have nothing whatever to gain?

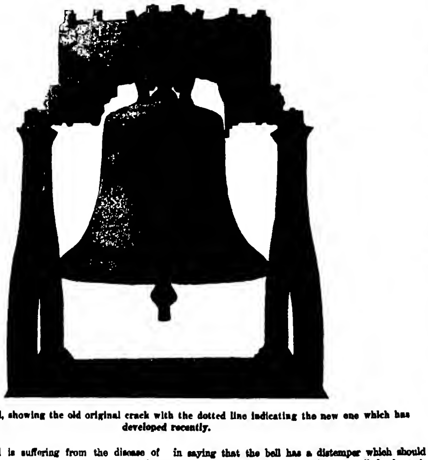
From an economic, a moral, or a patriotic point of view, the responsibility for and the financial burden of making coal-tar dyes in this country rests squarely and solely upon the users of dyestuffs, and in no wise, whatever, rests upon the chemists or the makers of chemicals in this country.

To bring the matter up squarely before you let me recapitulate: The 10,000 chemists in the United States are engaged in pursuits which affect over 1,000,000 wage-earners, produce over $5,000,000,000 worth of manufactured products and add $1,725,000,000 of value by manufacture each year; the business in products of and for chemical industry between the United States and Germany alone in 1913 provided 5 per cent of our total foreign business and 13.8 per cent of our balance of trade for that year. Please bear in mind that I am not by any means attempting to claim all the credit for this for the chemist; all that I ask is that his claims to recognition for intelligent, active and effective collaboration in bringing about these stupendous results be not thrown aside as worthless, and that he shall not be made the target of unjust criticism because in 1914 there was a shortage of about $900,000 or 7 per cent in coal-tar dyes and because cotton dropped from 15 cents to 6 cents.

Much more could be said of the chemist and his contribution to the effective every-day labor of this work-a-day world, but time and space forbid. I am sure that this short sketch of the chemist's activities, his hopes, his aims, and his work will serve to create a wider interest in him and will result in according to him the credit to which he is entitled, namely, that he pulls more than his own weight in our nation's boat.

The Liberty Bell and Diseases of Metals*

How Re-melting, Unscientific Methods and Mixtures Have Injured the Relic



The Liberty Bell, showing the old original crack with the dotted line indicating the new one which has developed recently.

The Liberty Bell is suffering from the disease of metals. This has been clearly brought to the attention of the public by the recent strenuous agitation to obtain permission for its removal to the Panama-Pacific International Exposition at San Francisco. The fact that the bell has been transported several times to various expositions has lent courage to the agitators.

Opponents of its removal from Independence Hall, Philadelphia, contend that if the bell is to be preserved intact as a sacred relic, it is absolutely necessary that it should be safeguarded as far as possible from all vibration; that it has already suffered irreparable injury from previous journeys to New Orleans in 1885, to Chicago in 1893, to Atlanta in 1895, to Charleston in 1902, to Boston in 1903 and to St. Louis in 1904.

In 1909 when the city council of Philadelphia seemed determined to send the bell to Seattle, Wash., those opposed sought expert metallurgical advice, for it had been observed that, in addition to the old vertical crack, a new crack had developed in comparatively recent years, starting from the top of the old crack extending diagonally around the upper portion of the bell, more than a quarter of its circumference. At first this new crack could only be seen by the aid of a magnifying glass, but it is now plainly visible to the naked eye, as indicated by the dotted line in the illustration. The curator of the museum where the bell rests applied to the Franklin Institute for an expert opinion as to the new crack and he was referred to Alexander E. Outerbridge, Jr., of Philadelphia, a metallurgist of distinction. The result of Mr. Outerbridge's investigation then was that the bell was kept at home. His recommendation, that it be supported on four padded stilts to relieve the strain which was gradually pulling the bell apart while hanging from the yoke, was adopted with beneficial results and to the satisfaction of many.

Vigorous protests were voiced early in February when it became known that various Philadelphia councilmen were planning to introduce into the municipal legislative bodies a bill to send the bell to the Panama Exposition. As in former trips this excursion, it was contended, would again afford a delightful trip of a few officials to the fair at the expense of the city. Through the efforts of the Daughters of the American Revolution, Mr. Outerbridge was again brought into the contest, and he submitted an expert opinion on the present condition of the bell and against its removal. Extracts from this interesting report are as follows:

It is no hyperbolical figure of speech to say that the venerated Liberty Bell is afflicted with a serious disease. Metallurgists have adopted into their technical phraseology the term "diseases of metals," and recognize several such maladies. I, myself, have no hesitation in saying that the bell has a distemper which should insure its most careful preservation from all shocks such as it would be subjected to in a long journey. It is only necessary to take a brief glance at the history of the bell to understand the cause of this malady.

THE FIRST CASTING OF THE BELL.

The bell was first cast in London by one Thomas Lester on the order of three eminent men, Isaac Norris, Thomas Leech and Edward Warner, then superintendents of the State House. It arrived in Philadelphia in 1752, and was tested in August of that year. Mr. Norris states: "It was cracked by the stroke of the clapper without any other violence, as it was hung up to try the sound. . . . When we broke up the metal our judges here generally agreed it was too high and brittle. We concluded to send it back by Captain Budden, but he could not take it on board, upon which two ingenious workmen undertook to cast it here, and I am just now informed they have this day opened the mold and have got a good bell, which, I confess, pleases me very much." Mr. Norris further states that in order to toughen the alloy, which was evidently too brittle, about 10 per cent of copper was added to the metal of the original bell when re-melting it. In a subsequent letter to the colonial agent in London, Mr. Norris wrote: "After it was hung in its place it was found to contain too much copper, and Pass & Stow, the workmen, were so teased with the witticisms of the town that they asked permission to cast it over again." Mr. Lester also offered to make another bell, taking back the metal of the defective one in part payment, but it was decided to give Pass & Stow, who, by the way, are said not to have been bell-founders by trade at all, another chance.

They re-cast the bell, adding, without doubt, a quantity of tin to restore the tone which the excess of copper had entirely destroyed. The third bell proved to have a high sonorous quality, and Pass & Stow were then paid £60 13s. 5d. ($295.25) for their labor. It is probable that the effort made to increase the resonance was overdone, for bitter complaints against the loud and harsh clamor were made to the Assembly. One petition, signed by "divers inhabitants," complains that they were much distressed by frequent ringing of the great bell, "and beg to be relieved from this dangerous inconvenience, except at the time of the meeting of the Honorable Assembly and of the Courts of Justice."

We have no record of the final composition of metals employed by Pass & Stow, but we do know that they must have used at least two dozen of the largest crucibles or melting-pots then known, in order to melt more than 2,000 pounds of metal required. Under these circumstances, the casting cannot possibly have been of homogeneous composition, and the bell was, therefore, subject to abnormal shrinkage and cooling strains, which actually caused a great crack to occur at a time when the clapper was muffled in tolling a solemn dirge on the occasion of the funeral solemnities of the first Chief Justice of the Supreme Court of the United States, John Marshall.

Had the bell been allowed to remain at rest after the disease had thus shown itself in a great crack extending about two-thirds of the distance from the lip to the top (being arrested by the somewhat thicker metal of the word "Philadelphia"), the new and more dangerous crack extending diagonally around the bell from the letter "P" in Philadelphia to beyond the letter "Y" in "Liberty," would probably not have occurred, for it was never observed until after the bell had made a number of peripatetic trips around the country, escorted by city fathers and policemen.

CAUSES OF THE DISEASE.

Failures from cracking even of the best quality of "Government bronze" castings, made under careful supervision are by no means unknown to-day, and it is not at all surprising that our venerated Liberty Bell, *having passed three times through the melting pots* and having been "doctored" by amateurs in metals, should still have traces remaining of the disease which caused its decay more than a century ago, and it behooves us, therefore, to guard this precious relic against all avoidable risks in the future for the sake of generations yet to come.

In conclusion, I wish to offer in behalf of future generations a warning to our present city fathers that if they pass a bill to send the Liberty Bell to the Panama Exposition for "the edification and inspiration of the nation," they are inviting disasters that may bring upon them anathemas instead of praises of the present generation as well as of all future citizens. Rather should they pass a bill prohibiting removal in the future of the bell from its peaceful resting-place in its proper home, Independence Hall.

The Daughters of the American Revolution were consulting counsel with a view to getting out an injunction in case the council passed the proposed bill. On account of this report of Mr. Outerbridge the bill was not presented to councils, as contemplated, on February 4th, and it is probable the bell will remain in its proper resting place.

The abstracts of Mr. Outerbridge's report that were printed in the Philadelphia daily papers inspired several inquiries from him as to the disease of metals. In reply to these Mr. Outerbridge, who considers the term an accepted one in metallurgical phraseology and science, published the following communication in the daily papers:

"Recently an abstract of a report I made at the request of a member of the Philadelphia branch of the Daughters of American Revolution on the present condition of the Liberty Bell containing the foregoing phrase appeared in the *Public Ledger* and other daily papers. Since then I have received several inquiries regarding this statement, which appears fanciful, if not absurd, to persons who maintain that there is a definite boundary line, between living and non-living matter. Without entering into any argument on this debatable topic, I wish merely to refer such doubters to the famous 'Faraday lecture' delivered by the celebrated Prof. Ernst Cohen, of Utrecht, on the 'Tin Pest,' before the Royal Society, London, in August, 1911, and reported in full, with numerous illustrations, in the *Mechanical Engineer*, April 19th, 1912, SCIENTIFIC AMERICAN SUPPLEMENT and other technical periodicals.

"DISEASE OF TIN.

"*Engineering*, London, November 3d, 1911, contains a long editorial review of this remarkable address, in which it refers to the fact that the main facts of the decay of the metal tin were known half a century ago. 'Erdmann noticed in 1851 that some organ pipes in the castle church of Leitz (Prussian Saxony) were decaying; he thought that the concussions to which the pipes were subject might, under certain conditions, cause a mechanical disintegration.'

"Referring to Prof. Cohen's modern researches on the changes taking place in pure tin from the brilliant normal condition of the metal to a gray powder when exposed to cold weather for some weeks, the editor says: 'Every particle of gray tin becomes a center for the formation of more gray tin; the transformation advances very slowly in the dense metal, but each particle of gray tin acts like the germ of a disease, and in this sense it may be said that the tin is infected, and that all tin is liable to infection with the tin disease or tin pest. In the cold galleries of museums the danger of tin infection is

* From the *Iron Age*.

peculiarly great and this museum disease is prevalent.'

"In the discussion following the address two of the most eminent living scientists, who have contributed much knowledge about the molecular structure of metals through their original researches (Prof Ewing and Doctor Rosenheim), referred to 'strain diseases of metals,' and Prof. Cohen said in reply that he had purposely not referred to 'strain diseases' in order to avoid confusion

"The foregoing brief references will suffice to show that my statement that 'metallurgists have adopted into their technical phraseology the term diseases of metals is abundantly corroborated by eminent authorities on metals in Europe

EFFECT OF RE-MELTING COPPER.

In further substantiation of this theory Mr Outerbridge says that since writing the above he has seen a report of tests made in re-melting pure copper several times under careful conditions With each melting the metal lost largely in tensile strength resilience etc Bending tests showed loss of over 50 per cent from three meltings The Liberty Bell was recast three times

Early in April last year four additional supports were placed in the case in which the bell now rests further relieving the strains The beneficial effect says Mr Outerbridge was soon apparent in a partial closing of the crack Should it be again sent on a railroad journey across the continent it is by no means unlikely that it would arrive there in two pieces

On February 11th the voice of the bell was conveyed by telephonic communication over 13 600 miles of copper wire from Philadelphia to San Francisco 3 400 miles It was the first sound that journeyed across the entire length of this continent and it was the first time that the ancient bell has pealed officially since it cracked tolling the death of Chief Justice Marshall 80 years ago

The Lincoln Beachey Monoplane

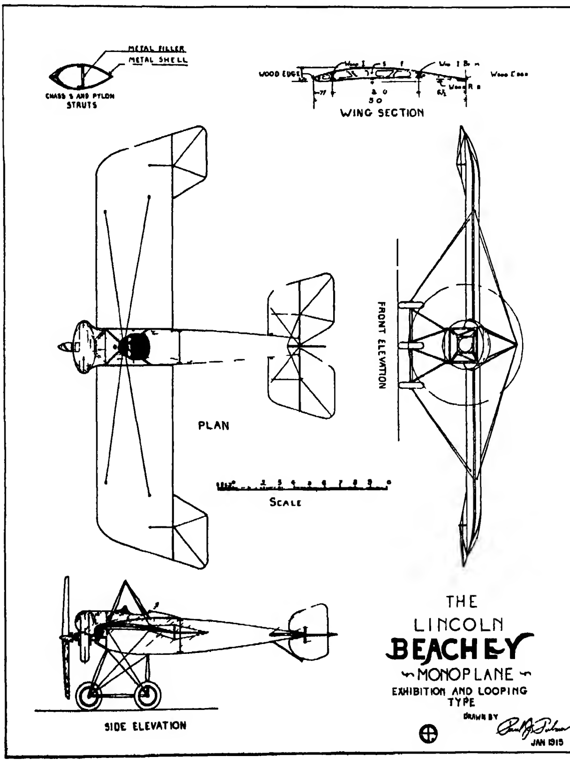
Details of a Composite Design That Failed From Weakness

LINCOLN BEACHEY, the daring aviator who recently lost his life when performing at San Francisco through the collapsing of the wings of his monoplane, had up to the present season used biplane machines exclusively for all of his exhibition work. This year he brought out a monoplane of his own design which was built for him by W S. Eaton of San Francisco in which the primary objects were to produce a machine that could be rapidly assembled and knocked down for convenience in his exhibition work, and also to enable him owing to its extreme lightness to climb very rapidly and almost vertically In his anxiety to secure these features it is evident that too much strength was sacrificed, with the fatal result above noted. This new machine which is said to be a sort of conglomoration of Antoinette Nieuport, Deperdussin and Etrich features is described by Paul J Palmer in *Aircraft* as follows (this description was written some time before the accident)

Span over all ailerons included 27 feet 6 inches actual wing span, 26 feet 6 inches height over all 8 feet length over all, 18 feet chord of main planes 5 feet effective hitting surface 110 square feet weight light, 510-525 pounds, angle of incidence for best speed 0 degree to ½ degree for best climbing 6 degrees horse-power 80 Gnôme thrust 650 pounds 7 feet 9 inches by 7 feet 4 inches pitch propeller speed minimum, 45 miles per hour maximum 100 110 miles per hour gliding angle 1 in 5 to 1 in 8

The main plane is in two sections each 12 feet long with 5 foot chord, and total effective surface of 110 square feet The plane shape is efficient and gives a very birdlike appearance when in flight The section is calculated from late N P L data and should give great speed The camber of the section is 1 inch on bottom and 3¼ inches on top the entering edge being turned up a trifle *à la* Nieuport

The construction and workmanship is beautiful to behold and follows general monoplane practice Spruce is used as the chief material of construction The ribs are built up with spruce rib bands and a cut out wood filler bored out to lighten The main ribs are spaced on 10 inch centers and half way between these main ribs are placed wood strips running from entering to trailing edges then half way between the rib band and



the main rib is placed a "false" rib extending from the front spar to the entering edge. This strengthens the "nose" and helps keep the covering taut. The spars are spruce I-beams, taper toward the outer end, and are spaced 2 feet 10 inches apart. The entering edge, 7½ inches in front of the front spar, is of wood, while the trailing edge, 1 foot 1½ inches back of rear spar, is of steel tubing, save where the ailerons attach, which is of wood. The covering is Irish linen, "doped" with Christofferson surfacing varnish which gives a fine tight glossy surface. The planes are internally wired with steel cable, and are fastened to the fuselage by means of quick detachable clamps designed by Mr. Eaton. The plane guy wires, total number of eight, are extra heavy steel cable, and run to a cabane or pylon on top to the landing chassis on the bottom. No dihedral angle or "aft" slope is given to the planes, for Mr. Beachey doesn't want a "stability" machine, he wants something that he can place in any position with no counteracting tendencies on the part of the plane.

The fuselage proper is 12 feet 9 inches long, 2 feet 3 inches deep, and 2 feet 3 inches wide, tapering as shown in drawings. The beams taper toward the rear, and all struts are streamlined in case Mr. Beachey desires to remove the covering for better maneuvering ability. The first layer is built in two sections, which are 8 feet and 5 feet 9 inches long, each, back and front, respectively. The connections at the joint are designed for quick detaching and are extremely strong. The fuselage is trussed with cable. The fore part of the fuselage is covered with sheet aluminium with a specially shaped "hood" covering the Gnôme motor which is noted for the oil shower "bawth" it gives to the personages "astern" of her. The aluminium hood runs back and forms a small cockpit for the pilot. The pilot's head will just appear above the rim of the cockpit. Padding is placed around the coaming to protect the pilot in case of rather "sudden" cessation of forward motion. The airman's seat is 6 inches above the floor, with the foot rest right back of the Gnôme bedplate. A small windshield fitted with celluloid "light" is put on to help out in landing and to protect from the wind pressure.

The landing device is a three-wheeled type, fitted with 20-inch by 4-inch tires. The wheels are especially constructed to cut down resistance. The rear wheels are spaced 5 feet apart, while the front wheel is 3 feet 10 inches in advance of the rear ones. Steel streamlined separators and struts are used to attach to the fuselage as shown in drawings. The chassis acts as the "pylon" for the lower plane guys. Altogether, the chassis is a strong, simple, and very compact arrangement.

The control planes are a marvel of constructive art. Steel tubing is used for the outer edges, with spruce ribs and attaching edge. They are solidly guyed with cable. Mr. Beachey is "heavy" on standardization, and consequently the ailerons and elevating planes are interchangeable. This reduces the number of extra parts to be "packed" around the country, several ailerons or elevator flaps, whichever you want to put it, sufficing to make repairs.

Ailerons and elevator flaps are semi-trapezoidical in shape, with rounded ends. They are each 2 feet 3 inches chord, by 4 feet on attaching edge, and 3 feet 6 inches on trailing edge. The effective area of each plane is about 8 square feet. The ailerons are operated simultaneously by means of the Curtiss shoulder-yoke, the control wires running through tubing placed inside the main planes, and passing around pulleys. The elevators are controlled by the back-and-forth movement of the steering column.

The rudder is 3 feet 6 inches by 2 feet 6 inches, with an area of about 7 square feet, operated by the wheel, on steering column.

The stabilizer is in two sections, each 3 feet 6 inches by 2 feet, with an area of about 12 square feet, total. They are attached to the fuselage by special clips. The section is the same as the main surface, proportionally reduced.

The power equipment consists of an 80 horse-power Monosauppe Gnôme motor, direct connected to a 7-foot 8-inch diameter, by 7-foot 4-inch pitch propeller, which revolves at about 1,200 revolutions per minute. The mounting is a special constructed bed-plate, fastened securely in the fuselage. The fuel tank is placed under the "cowl" and is force fed to the "mixer."

Gyrostats and Their Lessons

Studies of Various Forms of Apparatus

Lord Kelvin's work was so comprehensive and many-sided that it is difficult to gain an adequate conception of its noble proportions and varied character. It is like a mountain that presents many aspects as it is approached from different directions, and everywhere towers above the nearer objects that at times intercept the view. In the Kelvin lectures we have the opportunity of studying some one aspect of his teaching and genius, and of correcting any mistakes in perspective that forgetfulness may have introduced. Prof. Andrew Gray, F.R.S., an old pupil and collaborator, selected for the sixth commemorative lecture, delivered by him on the 28th ultimo, the subject of gyrostatics, one that appealed to Lord Kelvin, both on account of the ingenuity of the mechanical devices by which he illustrated it and the completeness of the theoretical explanations he was able to provide.

At the outset, the audience were reminded of a prominent feature that not infrequently characterized the lectures of the great physicist; he would become so keenly absorbed in the behavior of his apparatus, that to his watchful eyes told its tale so thoroughly and clearly, that he was apt to forget that his class needed some dynamical explanation to enable them to understand the curious evolutions they beheld. Those who were strong enough to follow the thought of the master, to bridge the hiatus, and to work out the problems he suggested, were, however, the gainers in the end, for it is good for a student to have his curiosity stimulated and to be compelled to find a satisfactory solution for himself.

The first attempt or experiment to arouse attention and promote inquiry, as the simplest, was directed to illustrating the truth of the oft-quoted formula, "Hurry on the precession and the body rises in opposition to gravity," though it may be said here that later in the lecture Prof. Gray showed that this statement needed qualification. A solid block of wood, whose surface may be imagined as generated by the revolution of an ellipse about its major axis, was made to spin rapidly about a minimum diameter. This block, at rest, is in stable equilibrium, when its shorter axis is vertical, but under the influence of rotation is stable when the longer axis is upright. It is a very remarkable result, for the center of gravity has been raised and the equilibrium is stable. The spin has altered the conditions of equilibrium completely. The puzzle to the uninstructed becomes more acute when the experiment is repeated with eggs, boiled and unboiled. The difference of behavior has been a mystery to many an audience, and probably will continue a popular experiment, till, as Prof. Gray hints, hens lay eggs oblate in shape. The unboiled egg, of the usual prolate form, will make no effort to rise on its end and spin about its longer axis, and the reason was pointed out by Colin Maclaurin two hundred years ago, when he first demonstrated the laws that govern the possibility of spinning ellipsoidal masses of liquid. To Lord Kelvin the spinning egg was a model of the earth, suggesting an infinity of problems connected with the genesis of our planet, the motion of tides, the rigidity of the crust, and the precession of the equinoxes. The main principle of this last has been illustrated times out of number by the phenomena exhibited by an ordinary top, when spun by a cunning hand, giving rise to the "sleeping" feature, and the rotation of the axis of figure about the vertical. Lord Kelvin went one step farther in his mechanical arrangement, and made his globe actually precess by weighting it with a pin projecting from the north pole, and rolling round a ring, thus making a narrow cone fixed in the earth roll in the inside of a cone fixed in space. Theoretically the subject was carried many steps farther, for the observed phenomena, correctly interpreted, could possibly throw light on the internal structure of the earth. In 1863 Kelvin had decided that the observed effects of precession were incompatible with an internally liquid earth. Simon Newcomb, however, suggested to him that viscosity might make the earth behave as if it were rigid throughout. This suggestion could not be lightly thrown aside, but as a direct cause viscosity is inadmissible. Indirectly, however, it is effective, for so far as precession affords a trustworthy index, rotation would induce the necessary rigidity in an internally liquid earth and make the axis move as in a solid globe. The conclusion at which Lord Kelvin arrived was that, if the ellipticity were not too small, the shell would not have more precession than the liquid, and that the compound rotating mass would move sensibly the same precessional motion as if it were a single rigid body. A fresh criterion to decide the true character of the earth's interior had to be found, and this was supplied by the solar semi-annual, and fortnightly lunar, nutations which would be materially affected by a possible internally liquid earth. Unfortunately, the numerical coefficients of these terms in the general nutational theory are small.

The examination of this and similar questions led to much work on liquid gyrostats, but before describing that type it will be well to follow Prof. Gray in his discussion of the ordinary solid form, indicating the improvements that have been made in its construction. Though everything that rotates may be called a gyrostat, the term is usually limited to disks of metal rotating on an axis and carrying a massive rim so as to increase as far as possible the moment of inertia. The flywheel, resulting from such an arrangement, is mounted in a cylindrical case, with extensions inclosing the axle, for which they are provided with bearings at the ends. In the older form these bearings were cups, in which the rounded points of the axle ran. This arrangement is defective, if the gyrostat has to be subjected to rough usage. In the improved form ball-bearings are employed, designed to resist considerable shocks and stresses without derangement. With a carefully made instrument, Prof. Gray states, the revolutions will number 25,000 per minute, and the flywheel will be found rotating rapidly after a lapse of forty-five minutes. Oiling, too, gives little trouble. The process of spinning has, likewise, undergone great changes. In Lord Kelvin's day, a long cord was laid along the floor and an attendant ran away with the free end as hard as he could. An improvement was effected by substituting a large wheel with a grooved rim, on which the cord was wound as it was drawn through the gyrostat. Now, of course, an electric motor is the only method in use.

When the gyrostat is spun successfully its peculiar motions can be well studied by suspending it from a cord attached to the rim, and hanging a weight to the part of the case surrounding the axle. In such a position the axis of spinning remains horizontal, and at the same time turns round in a horizontal plane. Strictly, the axis alternately descends slightly below and rises slightly above the horizontal, but a true horizontal motion can be maintained by properly starting the gyrostat in the azimuthal motion, and then leaving it to itself. This azimuthal motion of the axis is the characteristic precessional motion of the gyrostat. If the flywheel is set with its axis not horizontal, but inclined to the vertical, it has a precessional motion, in which the axis moves in a cone round the vertical. The peculiar behavior of the axis is often considered, by those unacquainted with the effect of torques or couples, as uncanny, and beyond ordinary comprehension. But in the particular case of horizontality, experiment will give a clue to the explanation. It is easily perceived that an attempt to retard the precessional motion makes the axis descend, and to accelerate it makes the axis rise, or that the horizontality of the axis depends on the freedom of the gyrostat to precess at a certain definite rate, depending, in fact, on the couple, applied by the weight of the gyrostat acting downward and the pull of the string acting upward, and on the angular momentum of the flywheel. The mathematical theory is not difficult to follow, but as Lord Kelvin thought that the true value of the experiment consisted in exciting the curiosity of the students and in awakening the desire to trace the reasons for the apparent anomalous behavior of the instrument, we will leave the problem with this hint.

It is, however, important to note, since it may be overlooked by the disciplined, that there are two possible precessional motions for the same spin and the same inclination of the axis of spin to the vertical, indicated in the theory by the two roots of a quadratic. One is large, the other small. One, called by Lord Kelvin "adynamic," does not depend upon applied forces; the other, called "precessional," does. "The motion is one of small oscillation about the steady motion, which is characterised by slow precession, . . . the other motion of the axis in the same cone is one of much greater precessional angular speed . . . the popular expositions which I have seen of gyrostatic steady motion as a rule ignore this second possible motion." Prof. Gray points out that the bald rule for causing a rotating body to rise by hurrying the precession is true only of the slower, more conspicuous precession. For the precession of greater angular speed, the reverse rule holds good. This qualification has not yet found its way into the text-books, and, therefore, no mention is made of the particular case of a horizontal axis where the precessional angular speed is infinite, and only the slow motion is realizable. As a

corollary, it should be remembered that if the center of gravity of the gyrostat is above the point of support, supposed on the line of the axis, the two precessional motions are in the same direction; if the center of gravity be below the support, in opposite directions; the faster motion changes sign in passing through an infinite value, when the axis is horizontal.

Lord Kelvin delighted in more complicated forms of gyrostat, or in forms to which additional mechanism lent greater complications. A favorite contrivance was one that demonstrated that an unstable arrangement can be stabilized by spinning. It consisted of a gyrostat supported on a universal gimbal joint in such a way as to form an inverted pendulum with two freedoms of motion, and when the wheel is unspun unstable in both. Spinning, however, gives stability to both systems, and illustrates a demonstrable truth—that in a gyrostatic system an even number of freedoms of motion can be stabilized by rotation of flywheels, but not an odd number. Experimentally this proposition was illustrated by an ingenious mechanism, which it was possible to arrange in such a way that there could be either one or two degrees of freedom. In the latter case, if both lateral and azimuthal motion be unstable, giving a very insecure support for a gyrostat, they can both be made stable by spinning; but when there is only one freedom to stabilize, spinning apparently loses its power.

Another form which might seem to indicate that a gyrostats conceals an imp of mischief consists in mounting the instrument on a hollow wooden square frame, supporting it by two trunnions in a line with the center of the wheel, placed on suitable bearings, permitting the axis of the gyrostat to rest with its axis vertical. If when the wheel is spun the whole frame is carried round in azimuth in the direction of spin, nothing happens; the gyrostat spins on placidly. But carry the frame round in the opposite direction, the gyrostat immediately turns upside down on the trunnions and remains quiescent, as at first; but the spin by the inversion of the gyrostat has been brought into the same direction as the azimuthal motion. Every time there is a reversal of the azimuthal motion on the part of the experimenter, so every time the gyrostat inverts itself, behaving as if it possessed a very decided will of its own, only exhibiting this one-sided stability and instability when it is affected by a precession impressed upon it from without. "The gyrostat had little or no gravitational stability—the center of gravity was nearly on a level with the trunnions; but even if it were gravitationally unstable, sufficiently rapid azimuthal motion would keep it upright if that motion agreed with the spin, while the least motion the other way round would cause it to capsize."

The applications of the gyrostat to physical inquiries, generally by way of illustration, are both numerous and interesting. Lord Kelvin's ingenuity found abundant scope, and since the chronological order followed by Prof. Gray has not been preserved here, it will be convenient to return to the suggested forms of "liquid gyrostat," by which it was proposed to test, or to illustrate, the possible deviation of the earth's interior from strict rigidity. In Kelvin's "liquid gyrostat," a spheroidal globe filled with water was substituted for the flywheel, the general mounting of the gyrostat being little altered. If the spheroid is oblate, with diameters in the ratio of 100:96, when it is spun, so far as regards precession, it behaves as if its contents were solid. But when the spheroid has about the same percentage of prolateness, since the fluid is not constrained to spin on its longer axis of figure, the spin disappears, and the peculiar features of gyrostatic action are not preserved. In consequence of the instability of the motion, the energy of rotation has been entirely transformed into heat by turbulent motion of the water, into which the rotational motion breaks down. Permanent steady rotation of such a spheroid is impossible. But, curiously enough, steady rotational motion of a liquid round the axis of figure is possible in a prolate spheroid if it be sufficiently prolate. The axial diameter, in fact, must either be shorter than the equatorial diameter, or more than three times as long. This fact was pointed out by Sir George Greenhill, apparently deduced from the study of ballistics as applied to the trajectory of a rifle bullet.

Another result in connection with geophysics was a gyrostatic device for furnishing an independent proof of the rotation of the earth. Foucault, as is well known, proposed two methods with this end. One consisted in observing the apparent turning of the plane of vibration of a long pendulum, suspended so as to be free as nearly as possible from any constraint due to the attachment of the pendulum wire to its fixed support. This experiment has been often described, and it is well known that if ω be the resultant angular speed, the component about the vertical at any place in latitude l is $\omega \sin l$. In the alternative method, Foucault availed himself of the principle that a rapidly rotating gyroscope will maintain the direction of its axis invariable, unless acted on by an extraneous force. He arranged a microscope to detect the apparent motion of a mark upon one of the gimbals, which shifted its position as the microscope was carried round by the earth's rotation. Lord Kelvin proposed to use the gyroscopic principle to observe the component of rotation about the horizontal, $\omega \cos l$, the companion component to that demonstrated by Foucault in the pendulum experiment.

Lord Kelvin's method of measuring $\omega \sin l$ consists in supporting a gyrostat on knife-edges attached to the projecting edge of the case, so that the gyrostat without spin rests with the axis horizontal. For this purpose the line of knife-edges is laid through the center of the flywheel at right angles to the axis, and the plane of the knife-edges is, therefore, the plane of symmetry of the flywheel perpendicular to the axis. The knife-edges are a little above the center of gravity of the instrument, so that there is a little gravitational stability. At points in a line at right angles to the line of knife-edges and passing through it, two scale-pans are attached to the framework, and by weights in these the axis of the gyrostat, without spin, is adjusted in a horizontal position, which is marked. The gyrostat is then removed, spun rapidly, and replaced. It is then found that the weights in the scale-pans have to be altered to bring the gyrostat back to the marked position. From the alteration in the weights the angular speed about the vertical can be calculated. The formula is very simple, but Lord Kelvin does not seem to have given any arithmetical estimate of the forces to be measured in a practical experiment. Prof. Gray supplies this information for a special case, where the mass of the flywheel is supposed to be 400 grammes, its radius of gyration 4 centimeters, and its speed of revolution 200 per second. If the points of attachment are 10 centimeters apart and the experiment is made in the latitude of London, a weight of 40.5 milligrammes would be required. In some of the larger specimens of gyrostat now in use, and with the same speed of revolution, it is possible for the weight to be as much as 8 grammes, showing that the idea is not impractical, though we have no estimate of the probable error of observation. If the line of knife-edges be made to pass accurately through the center of gravity of the system of wheel and framework, and the axis of rotation be placed so that the knife-edges are horizontal, east and west, the gyrostat will be in stable equilibrium when the axis is turned so that the direction of rotation agrees with the rotation of the earth; for the conditions of the experiment with the gyrostat mounted on trunnions, quoted above, are repeated. In the present case the hollow framework of the wooden tray is the earth, the position of the axis of rotation parallel to the earth's axis replaces the vertical position, and the earth's turning, the azimuthal motion of the experimenter. It is not difficult to show that the gyrostat could be made to imitate exactly the behavior of a magnetic needle in the earth's magnetic field, thus realizing Lord Kelvin's gyrostatic model of the dipping-needle.

The analogous properties of the dipping-needle and gyrostat would naturally suggest that a frictionless gyrostat might be arranged as an accurate compass. Such an apparatus Lord Kelvin seems to have contemplated in his "Gyrostatic Model of a Magnetic Compass." He proposed to hang a gyrostat, with its axis of rotation horizontal, by a long, fine wire attached to the framework at a point over the center of gravity of the system, and held at the upper end by a torsion-head capable of being turned round the axis of the wire. By means of this torsion-head any swinging of the gyrostat in azimuth round the wire was to be checked until, when the head was left untouched, the gyrostat hung at rest. The realization in practice was not unattended with difficulty. Lord Kelvin suggested that, in consequence of the high virtual moment of inertia of the gyrostat, when vibrating about the vertical wire, difficulties would arise, and he proposed a simplified manner of realizing a gyrostatic compass free only to move in a very approximate horizontal plane. Apparently there is no record of his improved plan, but the substitution of a "properly planned floater" as an alternative to the wire arrangement has since been realized in the gyro-compasses of commerce.

Another analogy of a striking kind is manifested by mounting a gyrostat as the bob of a pendulum, with its axis of rotation directed along the suspension rod. Without rotation, the two freedoms of this system are stable, and if the bob be made to describe a circle about the vertical through the point of support, the period of revolution is the same for both directions of the circular motion. When the gyrostat is spun, circular motion may take place in either direction, but the periods are quite different, that of the circular motion in the same direction as the rotation being the greater. The combination of the two circular motions under varying conditions gives rise to striking figures, traced by the bob, the interest of these being greatly increased by the analogy between the pendulum graph and the motion of an electron in a magnetic field. The parallel occurred to Lord Kelvin, but he decidedly rejected the gyrostatic explanation on account of the definite complex of spectral lines always observed in the Zeeman phenomena. The peculiar action of the magnetic field could not be explained by any scheme of infinitesimal gyrostats, the different inclinations of whose axes to the direction of the field ought to result in a hazy broadening or duplication, instead of a definite multiplication, such as many spectral lines undergo.

The employment of a pendulum and the thought of the action of minute gyrostats to explain various physical phenomena were utilized at an early period in Lord Kelvin's career. He employed this mechanism to illustrate "The Magnetic and Helicoidal Rotatory Effects of Transparent Bodies in Polarized Light." His object was to explain the rotation of the plane of polarized light transmitted through a solution of sugar, or across a plate of quartz cut at right angles to the axis of the crystal, as due to a helical structure of the medium, while the rotation of the plane by passage of the light through a piece of heavy glass along the lines of force of a magnetic field must be explained by rotational motion already existing in the medium and compounded with the motion produced by the wave of light. If on a superficial examination the rotation of the plane appears to be similar in the two cases, making it unnecessary to invoke two separate mechanisms, there is one point of difference which is decisive in requiring both a rotational and a structural explanation of the different phenomena. A beam of plane polarized light which has traversed a piece of heavy glass in a magnetic field will, if it be reflected and sent back through the medium, have the turning of the plane doubled by the backward passage, while backward passage through quartz or a sugar solution annuls the turning produced by the forward passage.

In this explanation one has to contemplate the possibility of helical hollows of the order of 1/10,000 inch in diameter with all their axes turned the same way, but in other connections Kelvin invoked the assistance of minute mechanism to illuminate many difficult problems, among which stands out prominently the suggested explanation of the manner in which two circularly polarized waves having turnings in opposite directions give a turning to the plane of polarization of the wave of rectilineal vibration, which is the result of their superposition. In quite a different connection a similar thought appears in the kinetic theory of elasticity. In this latter case he conceived the idea that the rigidity of bodies, their elasticity and shape, depend on motions of the parts of the bodies hidden from our ordinary senses, as the flywheel of a gyrostat is hidden from our sight and touch by the case.

The views of physicists undergo change as new facts are discovered and new conceptions entertained, and some modifications in the reasoning and conclusions may be necessary. How far Lord Kelvin's position is tenable time will decide. But, as Prof Gray reminds us in eloquent words: "Kelvin had confidence in his own theories and clung firmly to his conclusions. He could, however, on occasion acknowledge that he had made a mistake. His genius ranged over the whole field of physical science, no problem was too great or too small to attract his attention. No obstacles, no complications, daunted his spirit of inquiry. The thunders of Jove, the birth of the world, and the cold death prepared for it by dissipation of energy, the harnessing of the energies of Nature for the service of man, the guidance and safety of mariners, the genesis of waves and their breaking into spray and spindrift; all these questions, and many others, engaged his thoughts, to the lasting benefit of humanity and the increase of knowledge. Throughout all he was keen and calm and dispassionate, a truly unaggressive and *debonair* natural philosopher.

"The function of science is to enable man to penetrate the secrets of Nature, and to apply that knowledge to the promotion of the welfare and happiness of all living beings. No one would have repudiated with more scorn than Lord Kelvin that emanation of the pit, the modern doctrine that culture, scientific, philosophical, or artistic, entitles a self-appraised and self-chosen nation to wade through seas of blood to the dominion of the world."—*Engineering*.

Electric Cars in Belgium

MANY of the railway lines between France and Belgium intersect the trenches, and regular trains cannot be run in those localities; but the Germans have utilized these lines by bringing in cars operated by storage batteries and operating them singly to remove the wounded from the battle front, and to bring back supplies.

On Color Sensitized Plates

It used to be customary to draw three curves above a diagrammatic spectrum, heat, luminosity, and actinism curves, the last representing the power of light to produce or facilitate chemical change independently of the temperature change. This custom survives to a certain extent, though only one of the curves, namely, the heat curve, is definite. The luminosity curve depends upon the human eye, and eyes vary, sometimes even in the same individual, with regard to their sensitiveness to light and color. Still, it is possible to draw practically useful luminosity curves in a general sense, and by taking an average human eye, in perhaps almost an absolute sense.

But the "actinism" curve is essentially different for here we may be concerned, not with a single organ and its possible variations or degrees of perfection, but with every substance that exists on the face of the earth or that can be prepared by artificial means. And if we limit our considerations to the very few substances that are practically utilized in photography, we find that "actinism" extends from well into the infra-red down to the Röntgen rays, which are far below what is generally known as the ultra-violet. "Actinism" extends over a range of 11 or 12 octaves for practical photographic purposes, while luminosity extends over scarcely one octave, and for practical purposes even less than this, and yet some people speak of the photographic plate as color-blind!

The whole of this 11 or 12 octaves has not yet been dealt with photographically, because in the extreme ultra-violet (the "Schumann region") at wave-lengths a little less than 200 $\mu\mu$, the absorbing power of air and gelatine prevents the passage of radiations through them. But this appears to be due to absorption bands, as radiations of still shorter wave-length (Röntgen rays) pass freely through these media. By getting rid as far as possible of air and gelatine, the photography of the ordinary spectrum has been extended down to wave-length 100 $\mu\mu$, or even less. There are other difficulties than the air and gelatine to contend with in investigations of this region, but with these we are not immediately concerned.

Although it is necessary sometimes to bear in mind the enormous range of sensitiveness of photographic materials, even from a purely practical point of view, if we exclude the Röntgen region, and regard only those circumstances that concern the photography of objects, whether terrestrial or celestial, and whether by daylight or artificial light, we have to consider only about two octaves of radiations, or rather more if the far infra-red is taken into account. This range may be still further curtailed when daylight or glass apparatus is used, on account of the absorptive power of glass and the atmosphere, and what remains may often be sufficiently described by indicating five regions, namely, ultra-violet, blue, green, red, and infra-red. The "blue" will include the indigo and violet and the "red" will include the orange, and the yellow is negligible as in a good spectrum it is represented by little more than the sodium D lines.

In order to photograph colored objects so that their luminosities shall be correctly represented in the print, we want to get the curve that represents the action of the spectrum on the plate to coincide with the luminosity curve of the spectrum, and then we want a printing method that will preserve these tone values. The alternative of getting equal and opposite errors in the negative and the print so that the one shall correct the other, may have a degree of possibility about it. The fact to be emphasized is that the getting of a correct negative is not the whole business. Indeed, the getting of the two curves to correspond is not the whole business so far as the negative is concerned, for they may correspond at one exposure of the plate to the spectrum and not at another, because the steepness of the gradation of the deposits produced on the plate by equivalent ranges of exposures to the various parts of the spectrum is not the same. These difficulties are mentioned to show that, from a practical point of view, "orthochromatic" or "isochromatic" photography, or whatever it may be called, cannot yet even be regarded as an absolute matter; but where the discrepancy in the use of "ordinary" plates is of the order of a thousand to one, there is plenty of room and need for improvement, before getting, as it were, within sight of perfection.

When the spectrum is photographed on an ordinary plate, the green and red, which are bright to the eye, produce little or no effect; they might as well be black, while the blue and ultra-violet, which are dark and black to the eye respectively, produce a considerable effect, as if they were bright. Similar results are obtained with ordinary objects; slate roofs, being bluish, come much too light; bricks, being red or reddish, come much too dark; grass and green foliage too dark, and so on. The plate is sensitive to all these colors, but it is very much too sensitive to blue, or not sensitive enough to green and red. By causing the light that falls upon the plate to pass through a color filter that will reduce the brightness of the blue light to about 1/1000 part of its intensity, and increasing the exposure proportionately, the green and red will be given an opportunity to act, and the result will be much improved. To increase exposures to one thousand times the usual length may sometimes be possible (say two minutes instead of the tenth of a second), but the undesirability of such an increase need not be pointed out.

Dr. H. W. Vogel, in 1873, discovered that by the application of certain coloring matters, it was possible greatly to increase the sensitiveness of plates to green and to red light. About 10 years later the application of this principle began to be made a commercial matter, and Messrs. Edwards & Co. secured the patent rights in this country. These isochromatic or orthochromatic plates were a great step in advance.

There are two or three matters in connection with the use of such means as these to get variously colored objects represented according to their luminosities that may be pointed out as well from this example as from any other, bearing in mind that they represent general principles. Such plates as these ("ortho-" or "isochromatic") are often, if not generally, stated to be sensitive to yellow. This is misleading. Spectrum yellow, as already stated, is negligible in these matters. All objects that are yellow are yellow because they absorb blue, and send red and green light to the eye. Yellow light is a mixture of red and green. These plates have their sensitiveness increased to green and not to red. If, therefore, we so arrange our color filter as to get full correction for yellow, that is, that yellow and blue shall be correctly represented according to their luminosities, we throw the correction that ought to be borne by the green and red jointly entirely on to the green, and this color is therefore over-corrected. Greens will therefore be represented too light. On the other hand, the increased sensitiveness does not extend over the whole of the green; it is chiefly in the yellowish-green, and the curve of sensitiveness shows an important depression in the region that may be roughly indicated as being between E and F. Pure yellowish-greens tend, therefore, to be over-corrected on this account also, but what is perhaps of more importance is that a green that comes in this depression of sensitiveness will be under-corrected and come out too dark. This is not a mere theoretical difficulty, for M. Callier, who is a most careful investigator, finds that the green of pine trees largely corresponds to this deficient sensitiveness, while that of grass corresponds rather to the specially sensitized yellowish-green. Therefore these two greens are represented as more different in brightness than they really are.

These facts illustrate the difficulties that result from the fact that specially sensitized plates have not an evenly graded sensitiveness. There is the maximum for the plate, and a new maximum for the new compound introduced. Such irregularity might be compensated by a complex color filter, but of course only approximately and with much trouble and considerable increase of the necessary exposure.

The "ortho-" or "iso-chromatic" plates of commerce are generally of the type just discussed, and are sensitized by erythrosin or a similar substance. In a second article we shall refer to "panchromatic" plates and other matters.—Chapman Jones in *Nature*.

Business of the Canal

According to the *Canal Record* the business done by the Panama Canal for the first six months of its operation, that is from August 15th, 1914, to February 15th, 1915, has been entirely satisfactory. Four hundred and ninety-six vessels, other than canal vessels and launches, etc., which are not counted, passed through the canal during the period. They carried a total of 2,367,244 tons of cargo.

Slightly over 41 per cent of the cargo handled has been in movement between ports of the United States in what is classified as United States coastwise trade. Over 21 per cent of all the cargo has been in movement between the Pacific coast of North America, principally the United States, and Europe; and approximately an equal proportion (21 per cent) has been moving on the route between the west coast of South America and the seaports on the Atlantic seaboard of the United States and Europe. Traffic between the Atlantic seaboard and the Far East has amounted to over 12 per cent of the whole. All together, the foregoing routes have been used for the transit of all but approximately $2\frac{1}{5}$ per cent of all cargo sent through the canal.

The six principal commodities shipped through the canal have been, in order of their tonnage: Grain, nitrates, coal, refined petroleum products, lumber, and cotton. These six commodities together have amounted to approximately one-third of all goods shipped through.

The tolls levied during the six months' period amounted to $2,126,832.00. Adding to this the $11,610.69 of tolls collected on barges prior to August 15th, the total levy to February 15th, 1915, is $2,138,442.69.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, APRIL 10th, 1915

Published weekly by Munn & Company, Incorporated.
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876)	per year	$5.00
Scientific American (established 1845)	"	3.00
American Homes and Gardens	"	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

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We beg to advise our readers that we have discontinued selling numbers of the Scientific American Supplement dated earlier than January 1, 1914. We removed the first week in April to the Woolworth Building, New York city, and the change in our offices precluded the carrying of issues of the Supplement extending over a period of nearly forty years. It was, therefore, necessary to turn over this portion of the business to someone who has space for carrying so large a stock. The H. W. Wilson Company of 39 Mamaroneck Avenue, White Plains, N. Y., have been chosen to take care of our back number business. They have the complete stock and are ready to supply any of the back numbers at the standard price of 10 cents. We, therefore, request that, in future, all orders for Supplements be sent direct to the H. W. Wilson Company instead of ourselves. Please do not order Supplements on letters ordering subscriptions for the Scientific American or the Scientific American Supplement or books, or containing any other matters.

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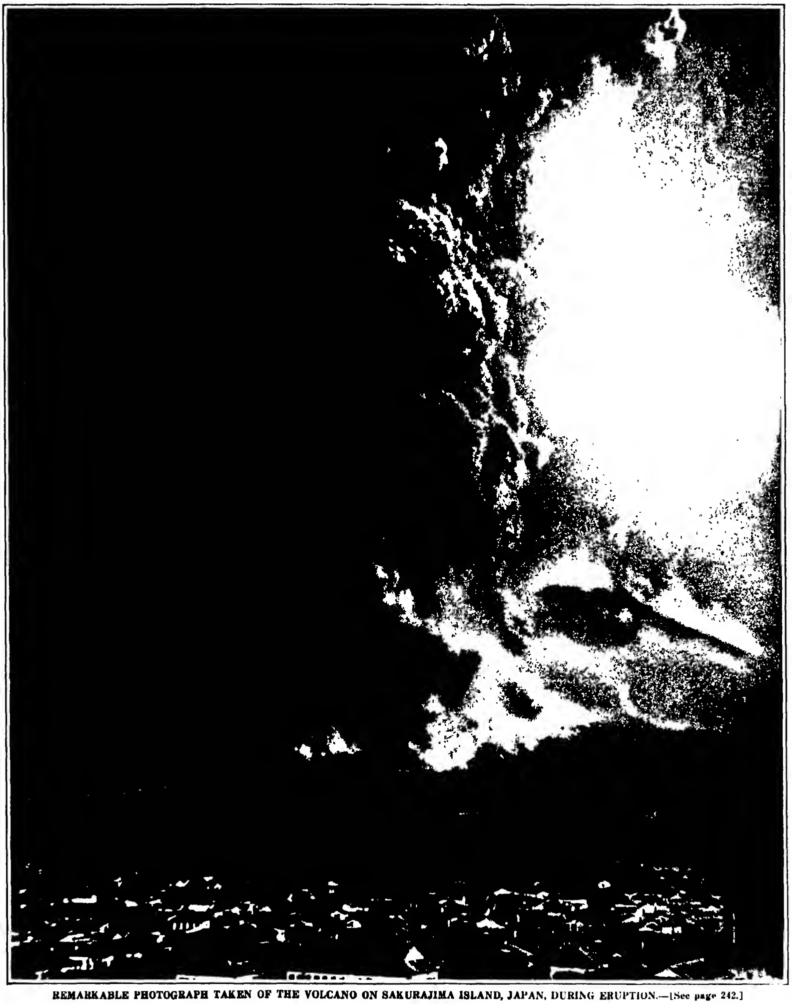
VOLUME LXXIX NUMBER 2050 | NEW YORK, APRIL 17, 1915 | 10 CENTS A COPY $5.00 A YEAR



REMARKABLE PHOTOGRAPH TAKEN OF THE VOLCANO ON SAKURAJIMA ISLAND, JAPAN, DURING ERUPTION.—[See page 242.]

The Sakurajima Eruptions and Earthquakes*

Abstract of a Memoir by Prof. E. Omori

SAKURAJIMA (Cherry Island), situated in Kagoshima Bay, and famous for its eruptions in 1779 and in several earlier years, was the seat of an outburst in January, 1914, which may be counted, in point of the magnitude of disturbance, as one of the greatest volcanic catastrophes of modern times. Many scientific men, Japanese and foreign, hastened to the scene of the outbreak; among them the writer of the present memoir, who, sent as a member of the Imperial Earthquake Investigation Committee, remained in the stricken district from the 16th to the 20th of January, and made a second visit in April. The following paragraphs give a short preliminary account, from the seismological point of view, of the Sakurajima eruption, the occurrence of which indicated the existence of a clear sequence among the various recent manifestations of volcanic activity in Japan.

Topography.—The island is irregularly elliptical, the greatest diameter in any direction being 11.4 kilometers. Near the center of the island there are two high peaks, the Minamidake ("south crater") and the Kitadake ("north crater"), respectively 1,060.6 and 1,133.5 meters in height. Together with a slightly depressed intermediate portion they form a ridge 1.8 kilometers in length running nearly in a north-south direction. Thus from the east or west the island looks like a truncated triangle and presents a beautiful Fuji type of outline with a flat top, while from the north or south it appears in the form of a pointed cone. There are several minor craters, lava promontories, and, in the adjacent bay, volcanic isles formed in connection with past eruptions. There are hot springs at several points on the southeast coast, and a mineral spring in the shallow sea water close to the beach of Saido on the northwest coast. The island had a population of 23,738, distributed in twenty hamlets.

Sea Depth and Mountain Size.—Sakurajima is a small volcano rising out of a shallow sea, the total volume of the island above the water level being 20.5 cubic kilometers, which will not be much augmented by adding the portion below the sea. Its magnitude is about equal to that of Ususan, but only about one eleventh that of Asamayama (i. e., the part of the latter above the plateau on which it stands), and about one fortieth that of Fujiyama. Its small size coupled with great activity probably means that the lava reservoir is at the slight depth of only a few kilometers, and that the frame of the mountain is comparatively weak for resisting an internal explosive condition; hence the unmistakable premonitory signs in the form of numerous earthquakes for several hours preceding the recent eruption, as well as that of 1779. Again, the eruptions were intense and of long duration, throwing out a great quantity of fluid lava, pumice and ashes, but the individual explosions were not quite so powerful as those of Asamayama.

Simultaneous or Successive Activity of the Different Volcanoes.—The four main Japanese islands, which form a simple arc with steep descent on the convex side into the deep basin of the Pacific, may be regarded as a volcanic chain or earthquake zone which is still undergoing stress accumulation. When the later reaches its limit, telluric disturbances may occur one after the other in various parts of the country in the form of great earthquakes or volcanic outbursts, as the case may be. The epoch of most violent eruptions in the history of Japan was an interval of fourteen and one half years between 1777 and 1792. There was first an eruption of Oshima, lasting, with intermissions, from August 22nd, 1777, to December 18th, 1778, with an enormous outpour of lava; then occurred the great eruption of Sakurajima on November 8th, 1779, with remarkable lava outflows and the formation of new islands; then Aogashima, one of the Izu islands, was in eruption from July 28th, 1780, to April 18th, 1785. Meanwhile, on May 9th, 1783, Asamayama broke out in strong eruptions, which terminated in a terrible downrush of "volcanic avalanches" on August 5th. Finally, the eruption of Unsendake, in Kyushu, began February 12th, and terminated May 1st, 1792, in a tremendous catastrophe, when the whole Southern slope of Maeyama was precipitated into the sea, causing great waves (*tsunami*) which cost 15,000 lives.

It will be noted that of the five volcanoes mentioned, two are in Kyushu, while the other three belong to the Fuji volcanic chain. In spite of the wide distance between the two groups the different volcanoes were thrown into great activity one after the other, and this was also true of the most recent series of eruptions.

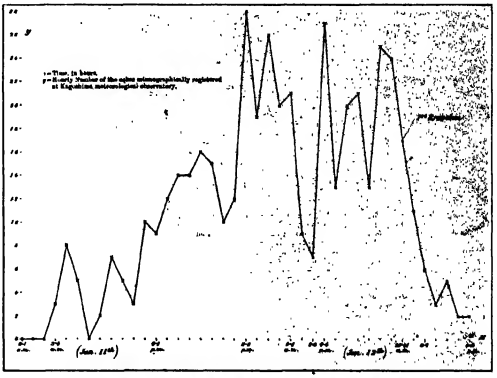
Recent Activity and the Sakurajima Eruptions.—An examination of the time distribution of the outbreaks of Asamayama indicates a recurrence of the epochs of greatest eruptive frequency with a mean interval of about 63½ years. Hence, twice this interval, viz., 127, or, say, 130 years, may also be regarded as a possible period in the frequency of eruptions, and it is noteworthy that Asamayama, Oshima, and Sakurajima, which had had no great outbreaks since the epoch of the eighteenth century just mentioned, have again exhibited, after a lapse of 130 years, a period of extraordinary activity.

In December, 1907, a period of eruption in the Fuji chain began with outbreaks of Yakedake, which were followed by a series of violent earthquakes and eruptions from Asamayama, beginning in 1908. In 1912 magnificent lava outbursts occurred from Oshima in March-April, and again in September-October. The explosions of Yakedake reached their climax in the summer of 1911, and ceased in the summer of 1912; the eruptions of Oshima ceased in the spring of 1913, and Asamayama apparently approached the final stage of its recent activity about the same time. The recent eruptive energy of the Fuji chain thus drawing to a close, the Kyushu volcanoes were expected, in view of their past history, to have their turn of activity. From May 19th, 1913, frequent small earthquakes began to be felt in the region at the northern and western bases of Kirishimayama, which had been quite for 10 years. This sudden appearance of seismic disturbances was at once interpreted as foreboding eruptions in Kyushu, and as early as June, 1913, the present writer urged the governor of the Kagoshima-ken to set up a sensitive seismograph at the Kagoshima meteorological observatory. Meanwhile the seismic disturbances extended to the peninsular part of Satsuma, and at the end of June a strong earthquake occurred some 16 kilometers west-northwest of the city of Kagoshima. On November 8th Kirishimayama broke into strong eruption; another violent outburst occurred December 9th; and a third January 8th, 1914. On the morning of the 12th the author received a telegram stating that 337 earthquake shocks had occurred in the city of Kagoshima between 3 A. M. of the 11th and 6 A. M. of the 12th. The author was about to telegraph instructions to Kagoshima urging that a careful watch be kept of Sakurajima, which could be the only cause of these unusual seismic phenomena, when press dispatches arrived announcing that the volcano had broken into eruption.

Premonitory Signs.—Unlike large destructive earthquakes, which originate along seismic zones, but are not repeated from one and the same center, the eruptions of a given volcano, whether occurring from the central crater or from new side vents, are at least localized to the mountain itself. Hence it may be that the great eruptions from a given volcano at widely different epochs resemble one another more or less, both in the eruptive phenomena and in the precursory events. Thus the sequence of phenomena in and preceding the Sakurajima eruption of 1779 was almost exactly duplicated by the events of the recent eruption, which will now be sketched briefly.

The accompanying diagram (Fig. 3) shows the hourly frequency of the earthquakes registered at the Kagoshima observatory, 10 kilometers distant from the center of Sakurajima, with an ordinary Gray-Milne-Ewing seismograph. The shocks were much more frequent, and were felt some hours earlier, on the island itself.

The hot springs, ordinary springs, and wells of the island were much disturbed on the 12th. White smoke was seen at certain places over the mountain as early as the afternoon of the 11th, and at 8 A. M. of the 12th a column of white smoke was suddenly shot up in the form of a pine tree from the south crater. In view of these unmistakable warnings, a general exodus of the inhabitants of the island began on the 11th. The prefectural authorities took prompt measures to aid their escape, and the result was that the entire population of more than 23,000 was brought safely out of danger, with the exception of two clerks of the village office of Higashi Sakurajima, who heroically remained until the eruptions had begun and were drowned in attempting to swim to the mainland.[1]



Hourly frequency variation of the earthquakes which preceded the Sakurajima eruption of January 12th, 1914.

Eruptions.—The first outburst took place from the west side of Sakurajima about 10 A. M. of the 12th from a point about 500 meters above sea-level, followed about 10 minutes later by an outburst on the southeast side. Red fire was seen from Kagoshima at the base of the smoke column 5 minutes after the eruption began; lava blocks were seen to be thrown out abundantly from 11:30 A. M.; and explosive detonations began to be heard at 3:30 P. M. The dense black smoke, which, the weather being calm, was finally projected to a height of 20,000 feet above sea-level, was traversed by lightning in various directions. Panic reigned in the neighboring city of Kagoshima, where wild reports were spread as to the poisonous effects of the volcanic gases, and apprehensions were also felt of *tsunami* (tidal waves); hence the majority of the inhabitants fled to the country. The explosive stage of the volcano reached its full intensity between about 11 P. M. of the 12th and 5 A. M. of the 13th, with a maximum at

* From the *Bulletin* of the Imperial Earthquake Investigation Committee, Tokyo.

[1] Compare newspaper reports, which, even some weeks after the eruption, estimated the loss of life on the island at 200, in addition to the persons who actually were killed by earthquake in Kagoshima.—Editor.

about 1 A. M. The detonations at this stage were so loud that the prefectural officers in Kagoshima had to stuff their ears with cotton. The eruptions on the west side of the island virtually ended January 25th, but those on the east have kept up their energy and are still (August, 1914) making occasional strong outbursts.

About seven principal craterlets were formed on the west and eight on the east side of the island; none higher than 509 meters. The lava which flowed from these was of very little fluidity, so that it is generally broken up into loose angular blocks. The main lava stream on the west side flowed down during the first two days at the rate of 45 meters an hour. On the east side the lava had, by the 29th, completely blocked up the strait separating the island from the mainland, thus converting Sakurajima into a peninsula. The eastern lava field ultimately attained an area of 15.41 square kilometers, of which 7.97 square kilometers is under water; the western field has an area of 8.33 square kilometers. The thickness of the lava is from 40 to 100 meters, and the total volume ejected is estimated at about 1.6 cubic kilometers, or about one seventeenth the volume of the mountain.

The precipitation of pumice and ashes was very abundant in the eastern part of the island, being deepest near Kurokami, where it amounted to 6 feet or more and buried the houses nearly up to the roofs. Ashes, carried by the westerly winds, fell in the Bonin Islands to the southeast, and northeast over most of Japan west of Mito and Utsunomiya, the extreme eastward radial distance being over 1,200 kilometers. The total volume of ashes and pumice is estimated at 0.62 cubic kilometer. This amount, added to the above estimated output of lava, gives a total equal to *one twelfth the volume of the mountain.*

Strong Earthquakes and Small Tsunami.—The strong earthquake which occurred at 6:30 P. M. on the 12th, and which cost 19 lives in Kagoshima, was recorded in Tokyo, and must have been of several times greater magnitude than certain earthquakes attending recent eruptions of Asamayama and Ususan, which had been supposed to represent the limiting intensity and size of a volcanic earthquake. It was probably, however, of very deep origin, and the result rather of the stress accumulation along the whole volcanic chain in southern Kyushu than of the Sakurajima eruption alone. An hour or more after this shock a slight inundation occurred along the harbor front of Kagoshima (at high tide). The direct cause of this *tsunami* was, however, probably a small, sudden settlement or depression of the bottom of the bay.

Tromometer Observations of the Eruptions.—A tromometer in operation at Kagoshima beginning with the 16th recorded the tremors due to the successive eruptions, and showed, among other things, that the explosions with loud detonation produced very slight seismic effects as compared with non-detonative eruptions. It is likely that the latter are much more important phenomena, and consist in the powerful projection of ashes and gases along pre-existing channels of deep extension.

Effects on Water Level; Depression of Coast.—The results of leveling by the Military Survey Department compared with heights determined in 1892 indicate that there has been a depression of the coast amounting to about 0.2 meter at Kagoshima, and reaching 0.67 meter at a small promontory about 10 kilometers northward along the coast. The greater part of the depression thus found may possibly be the result or precursor of the recent eruptions.

Arrangement of Craterlets.—The new craterlets extend in a zone running from west-northwest to east-southeast; i. e., at right angles to the axis of the volcanic chain of which Sakurajima forms a part. Hence the new vents pertain to a system of secondary fracture limited to the island itself. The formation of craterlets on two opposite flanks of the mountain, which also occurred in 1779 and 1476, indicates that it is easier for the eruptive energy of Sakurajima to find vents near the base of the mountain than to push up the internal lava to its top.

Activity Along the South Kyushu Volcanic Chain.—As already stated, the strong explosion of Kirishimayama, on January 8th, 1914, was followed quickly by the great Sakurajima eruption of January 12th. Then Iwojima, situated off the south coast of Satsuma, was the seat of an eruption February 13th, accompanied by several earthquakes, one of these being of fairly large magnitude. Finally, Suwanosejima, still further southward, had an eruption on March 21st. These four volcanoes are in nearly a straight line.

These eruptions have probably brought the volcanic activity in this part of Kyushu to an end for the time being, and the site of volcanic outbursts appears to have again shifted to the Fuji volcanic zone, where Oshima, after a quiescence of about a year and a half, gave rise to very powerful lava eruptions for about seven days in May, 1914.

Gasoline Locomotives

By A. H. Ehle

Gasoline locomotives for surface work have been in successful use for some six years and are mainly distinctive because of combining certain well-established steam locomotive principles with a source of motive power that has become highly developed through the introduction of automobiles. It is apparent that in a gasoline locomotive the object sought is to produce the maximum tractive effort or drawbar pull, the locomotive itself seldom being required to carry a load as in the case of automobile trucks. Because of the different conditions under which a locomotive must operate there is something more required than the mere incorporation of good automobile practice.

Gasoline locomotives have been particularly successful in work around contracting operations, plantations, quarries, smelting plants—in fact for almost all industrial purposes where loads are to be hauled at moderate speeds and within the range of available motor powers that can be placed within the gage limitations imposed. Obviously they are safe and unlike some other forms of locomotives independent of power sources external to themselves. However, notwithstanding their convenience and serviceability their more general introduction depends upon the economic consideration of first cost and fuel-operating expense compared to other available kinds of locomotives.

At present the Baldwin Locomotive Works are making four sizes of narrow-gage industrial machines weighing 3½, 5, 7, and 9 tons, having drawbar pulls on high gear, on level track, of 750, 900, 1,300 and 1,700 pounds respectively.

The locomotives are provided with two-speed transmission giving general speeds of 4 and 8 or 5 and 10 miles per hour in either direction. In addition to these sizes there has lately been developed a considerably larger or 18-ton machine built for standard gage only and having a three-speed transmission providing speeds of 6, 12, and 20 miles per hour in either direction.

Its guaranteed drawpull on low gear is 6,000 pounds, on middle gear 3,000 pounds, and on high gear 1,700 pounds.

An 18-ton machine, as above described, on test exceeded the specified drawbar pull or hauling capacity by about 50 per cent when operating on either gasoline or kerosene. It was designed for industrial switching service and to haul a total of about 200 tons on level track around 28-degree curves, or the equivalent of lighter loads up various grades. The consumption of either gasoline or kerosene was found to be in average service about 4¼ gallons per hour, hauling about 80 tons total back and forth over a track having level stretches and grades as high as 3 per cent. This particular fuel test was conducted for two hours, the locomotive pausing only long enough to reverse its direction at the ends of the runs. The loads were hauled on the low gear speed of 6 miles per hour. This locomotive has hauled a total of 234 tons up at 1½ per cent grade and around 25-degree curves at a speed of about 5 miles per hour.

The motors are all water-cooled and of the four-cycle four-cylinder vertical type, especially designed to withstand severe service. There is nothing radical about them; they conform quite generally to the larger motors used in automobile construction. They are almost invariably equipped with electric motor starters, after the manner usual in automobile practice. The ignition is by battery and automatic spark advance magneto.

The gears, shafts, clutches, and all other transmission parts are of very liberal proportions, since there is not the necessity of keeping down weight as in the case of automobile design. The running parts are inclosed in an oil-tight cast iron housing which constitutes a separate unit. In this way lubrication is easily provided for and the parts are permanently held in rigid alignment.

The main clutch is of the multiple-disk type, the purpose of which is the same as in automobile work. The alternate bronze and steel disks run in a bath of oil and the combined surface is extremely large for the horse-power transmitted. The clutch can be slipped almost continuously without excessive heating or perceptible wear.

The main frames are of the cast steel bar type and generally similar to those used in steam locomotive practice. They are naturally stronger than cast iron frames of equal weight, and because of their design the motor and running gear are more accessible.

The side- or driving-rods are of hammered steel with solid ends. A wedge adjustment is provided at the jack-shaft and a plain bronze bushing inserted by hydraulic pressure at the other end. The solid driving pin brasses in the yokes are free to move vertically without bringing any strain upon the rods.

An efficient interlocking hand- or foot-operated brake is provided with shoes on all the wheels. These shoes are of the M. C. B. type and detachable from the brake-heads, where desired air brakes also can be applied.

The radiator is substantially constructed with unusually large surface and water capacity. In appearance it is very much the same as those used on large automobile trucks. It is of such proportions as to prevent over-heating when developing full power under the most severe hauling conditions. Air circulation is maintained by a fan driven from the engine flywheel.

What are the prospects of expanding this type of locomotive into large sizes to take care of passenger and freight work now handled almost exclusively by steam locomotives? They are promising, but even after successfully solving such problems as sufficient power, available space, method of power transmission, etc., it must be clearly demonstrated that from an economic standpoint internal combustion locomotives can hold their own with the well established steam and electric types.

In the light of present experience and knowledge, however, it seems more probable that permanent results will be obtained by working in other directions. For instance, there are attractive possibilities in the use of a locomotive employing compressed air as the working medium. In such a machine the gas engine would be direct-connected to an air compressor delivering air to a suitable reservoir, the air from this reservoir being utilized in cylinders and with mechanism very similar to those of steam locomotives of the present time.

It may be that for internal combustion locomotives the prime mover itself will be used for quite a different purpose. Instead of endeavoring to produce the maximum amount of rotative effort at the engine crankshaft, the transmission difficulty may be obviated and the efficiency raised by producing directly from the fuel the maximum amount of exploded gas under pressure, which latter will then be conveyed to operating cylinders as in the case where compressed air is the working medium. The mechanism for producing this exploded charge may possibly follow present design with respect to the essential parts of the machine, but with such parts obviously intended for different purposes. At first thought it might appear quite impracticable to retain the heat and thus the energy so produced, but thus far it is not known what can be done by exploding a charge into a container constructed for the sole purpose of retaining its heat as long as possible—a container such as a vacuum bottle, for example.—*Engineering Magazine.*

Effect of Moisture in the Earth on Temperature of Underground Cables

In a paper on the above subject presented by L. E. Imlay at the Midwinter Convention of the American Institute of Electrical Engineers, and published in the *Proceedings* of the Society, the author describes a permanent installation which was made for supplying moisture to the earth in the neighborhood of underground cables with the object of reducing their temperature. The approximate temperature of the cables is found by taking with a resistance thermometer the temperature of a duct adjacent to the cable which is the source of heat. In uncovering the conduits and exposing them to air, as a remedy for hot spots in the cable, it was found that the adjacent earth was hot and dry so that it crumbled to powder. This suggested opening a ditch in the ground above the conduit and directing a stream of water through it. This was found to lower the temperature immediately several degrees. Where an open conduit was not practical, water was discharged into a vacant duct by means of a hose, and this was found to be more effective than the open ditch method.

These experiments led to the installation of a line of porous tile duct in the earth above the conduit, surrounded with clean sand. The leakage of water through the pores of this duct has been found very effective in reducing the temperature of the cables. Whenever the temperature of the cables is found by exploring with a resistance thermometer to approach the danger point, water is turned into the porous drain tile, and the temperature is taken on successive days to see whether the desired reduction has been obtained. In this way one or two men, with resistance thermometers attached to long leads, can keep track of and control the temperature of the cables in a large system. No breakdowns of insulation of cables have occurred due to high temperature since the adoption of this method.

Fig 1.—The essentials of a response recorder. Fig. 2.—General view of the resonant recorder. The thread from the clock passes over the pulley *P*, so as to lower the smoked recording plate *G*. The writing point is adjusted for distance by the screw *s'*; vertical adjustment is effected by the screw *S*, in order to adjust the plane of the recorder's movement parallel to the writing surface, a tangent screw *T* is provided. The picture shows also the electrical connections by means of which an excitatory shock of definite duration may be given to the plant by metronome which completes electrical circuit. Fig 3. The dotted line is correct, the continuous line incorrect, thus showing the advantage of intermittent over continuous contact in obtaining records. Fig. 4.—The effect of alcohol vapor, note the alternating character of the response after application. Fig. 5.—Effect of cold in inducing retardation and arrest of transmission: (1) normal record; (2) retardation due to slight cooling; (3) arrest of conduction brought about by intense cold; (4) record of direct stimulation. Fig. 6.—Effect of excessive absorption of water; note the prolongation of the period of recovery and the ineffectiveness of stimuli applied at moments marked with thick dots and subsequent restoration of excitability by application of glycerin. Fig 7 and 7a.—Preliminary staircase followed by fatigue in the response of frog's muscle (Brodie) and staircase response followed by fatigue in Mimosa (Bose). Fig. 8.—Effect of sudden darkness on the excitability of Mimosa; first three responses normal, four succeeding responses due to the effect of darkness; the line below indicates the period of darkness.

Testing the Sensibility of Plants

The Remarkable Investigations of Prof. Jagadis Chunder Bose

STRIKE an animal and it winces. Strike a plant and it remains apparently unresponsive. Yet in the folk lore of almost every nation both animal and plant life are poetically unified, and the one credited with sensations akin to those of the other. Even those scientists who deal with the psychology of lower animal forms have felt that there was no reason to assume that response to external excitation should suddenly cease with the very low animal form and be denied almost together to plant life. These vague suspicious have at last been transformed into positive knowledge, thanks to the very remarkable studies which Prof. Jagadis Chunder Bose of Presidency College, Calcutta, has conducted for a period of many years and which have opened up an entirely new field in plant physiology.

Prof. Bose approached his task as a physicist, as might be expected of one who had distinguished himself for researches on electric waves which have become classic. From a man who has succeeded in producing an apparatus for producing the shortest waves, thus bringing our instrumental knowledge of radiation within thirteen octaves of visible light, who has determined the index of the refraction of various opaque substances, who has shown how total reflection fails when the thickness of the air space between two substances is shorter than a certain critical value, depending on the index of refraction and the wave-length, who has demonstrated the possibility of polarizing electric rays by various crystals, who has constructed two kinds of artificial molecules, which like dextrose and levulose, rotate the plane of polarization of electric waves to the right or to the left, who has demonstrated how substances which are strained in concentric circles, such as wood with concentric rings, project into space a dark electromagnetic cross, analogous to the dark cross exhibited by crystals, like salicine—from such an investigator one naturally expects extraordinary results. Realizing that the instrumental study of plant physiology has been hampered chiefly by the crudity of the apparatus employed, Prof. Bose invented a number of original types of recorders and originated startlingly new methods of investigation, with the result that he was able to demonstrate that all plants are sensitive and that they respond to stimuli as well as the higher animals. To those who wish a detailed account of these remarkable studies, we would recommend the reading of Prof. Bose's "Researches on the Irritability of Plants."[1] Upon this work the statements made in the following paragraphs are based.

Because of its very conspicuous motility, Mimosa has been made the object of much study on the part of plant physiologists, notably Haberlandt and Pfeffer. Prof. Bose also began with Mimosa. It is the one plant which, in popular acceptance, is conspicuously "sensitive." It ought to be no very difficult matter, apparently, to construct an apparatus which would record the movements of that mass of tissue in Mimosa which is known as the Pulvinus. We might construct an apparatus as shown in Fig. 1, consisting of an axis, supported on frictionless jeweled bearings and carrying two arms of a horizontal lever and a thin vertical wire with a bent tip to serve as a stylus or writer. A point of the petiole of the responding leaf could be attached by a silken thread to one arm of the lever, the other having on it a small weight to act as a counterpoise. When the leaf falls under excitation it ought to pull down with it the attached arm of the lever, and if the finely pointed bent end of the writer were to press lightly against the smoked surface of a glass plate, allowed to fall at a uniform rate by means of clock-work, a curve would be traced, which would not only record the responsive movement and recovery, but also give their time relations. The parts can be so proportioned that the degree of magnification or reduction of the movement of the leaf, as it appears in the record, could be very readily determined. However light the contact may be between the stylus and the glass plate in the type of apparatus sketched in Fig. 1, and however smooth the glass recording surface, the record will be inaccurate because of the friction entailed. How can this be overcome, so that an absolutely accurate record, free from error, could be obtained?

"It occurred to me at last," says Prof. Bose, "that the problem might find a solution if I could succeed in making an intermittent instead of a continuous writing contact. I have solved this problem by devising two different types of apparatus, which I have called, respectively, the oscillating recorder and the resonant recorder. In the former, the recording surface itself is made by an electromagnetic device to vibrate to and fro, thus bringing it into periodic contact with the writing point."

The resonant recorder is shown in its entirety in Fig. 2. A thread from a clock, not shown, passes over the pulley *P*, letting down the smoked recording plate; by means of the screw *S'*, the distance of the writing point from the plate can be adjusted; the vertical adjustment is effected by means of the screw *S*. A tangent screw *T* renders it possible to adjust the plane of the recorder exactly parallel to the writing surface; the axis of the writer is supported at the center of the circular end of the magnet; *V* is the vibrating recorder; and *G* is the smoked glass plate.

The reason for this peculiar construction will become apparent when we consider the nature of the investigations which must be made. Time intervals of one hundredths of a second must be measured. Clearly a heavy plate carrier cannot be made to oscillate with such a high frequency. Hence, Prof. Bose resorted to the device of making the writing point vibrate to and fro at the required frequency, so as to make the necessary intermittent contacts with the surface of the recording plate. A writing point made to vibrate to and fro at right angles to the plate will in no way affect the record beyond that fact that, instead of a continuous line, a dotted line will be traced. There is no friction resulting from continuous contact, and hence the record is accurate. The recording point must be given an impulse exactly perpendicular to the direction of its recording movement. In order that the electromagnet shall be without laterality, Prof. Bose makes the pole of the electromagnet in the form of either a cylinder or a ring. The axis, from which is suspended the writing index, is accurately supported perpendicular to the plane of the circular section of the magnetic pole and its center. Thus, everything is made symmetrical, and as there is no laterality there can be no tendency whatsoever for the index to execute its to and fro vibrations in any other direction than that which is perpendicular to the plane of the terminal pole of the magnet.

There is still to be overcome the difficulty of the irregular timing of these electrical impulses, which are to maintain the recording index or writer in a state of periodic vibration. Prof. Bose employs a long steel reed which in the course of its regular vibration will periodically interrupt the electromagnetic circuit of the vibrator coil. The reed itself is maintained in a state of persistent vibration by the usual electromagnetic arrangement. This reed interrupter he calls a "coercer"; the writing index he refers to as the "vibrating recorder" or the "vibrator." Obviously, if the natural frequency of vibration of the recording index is known and if by means of some mechanism we can send periodic currents of exactly the same frequency through the electromagnet, then the intermittent magnetic pulls will exactly synchronise with the natural swings of the writing index. Owing to this perfect tuning the index will now resonate, breaking out into a persistent and regular vibration of considerable amplitude. The various frequencies most suitable for the recording index are found to be ten, twenty, fifty, one hundred, and two hundred vibrations per second.

The enormous advantage of intermittent over continuous contact is shown in the record reproduced in Fig. 3. These represent two successive experiments on

[1] Longmans, Green & Co.

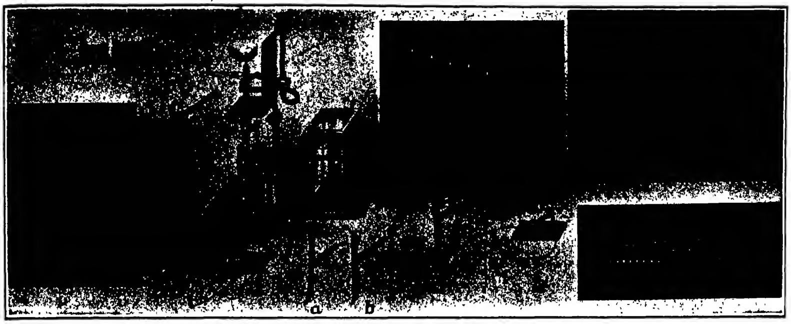


Fig. 9.—Strong carbonic acid gas, inducing arrest. The line below indicates the duration of the application Slow revival of pulsation on substitution of fresh air. Fig. 10.—Continuous record of pulsation of Desmodium leaflet for four hours; the series to be read from below to above. Fig 11 - Electrothermic stimulator for uniform stimulation; metronome is employed in place of key *k*, for closing circuit for a definite length of time (Fig 12.—Record showing growing fatigue of Mimosa. Fig. 13.—Direct stimulation by condenser discharge; *c*, condenser; *k*, key; *a*, intra-electrodal, and *b*, indirect extra-electrodal mode of stimulation Fig. 14.—How detached leaflet of telegraph plant is mounted to study pulsations. The petiole is mounted in the shorter open end of a narrow U-tube filled with water. The longer end of the U-tube consists of India rubber tubing By raising or lowering this longer limb the hydrostatic pressure can be varied. The stop cock allows the water to run out when chemical solutions are to take the place of water A light cover with mica windows can be made to inclose the specimen. By means of an electric current sent through a spiral of German silver the inside of the chamber can be heated to any desired degree. Fig. 15.—The death-curve of Mimosa. Successive dots in the down or expansive part of curve represent rise of temperature of one deg Cent. Spasmodic contraction causing inversion of curve takes place at 60 deg. Cent. with all plants. Fig. 16.—Arrangement for applying single make or break; *k*, key in the primary circuit. The secondary circuit may be short-circuited by the second key

the same leaf and identical stimulation—an electrical shock. The lower record was taken with continuous contact and the upper with the same recorder set in vibration so as to give intermittent contacts. The vibration frequency was ten times per second. A comparison of the record shows how enormous is the error due to friction. Moreover, it is obvious that the accurate dotted record is very easily interpreted, because the record itself contains its own time marks, the successive dots indicating intervals of one tenth of a second.

With the aid of this apparatus Prof. Bose has very accurately measured the response made by Mimosa and other plants under mechanical, chemical, thermal, and electrical excitation.

The thermal mode of stimulation deserves some explanation. It is illustrated in Fig. 11. A loop of the platinum wire is made to clasp around the petiole, which is to be excited, and is connected with an electrical circuit by means of fine flexible silver wire. The circuit can be completed by a metronome interrupter, the current of the battery flowing for a definite length of time during, say, a single or definite number of beats of the metronome. Successive uniform stimuli can be thus applied. Another practical method of stimulation is that of condenser discharge shown in Fig. 13. The condenser consists essentially of two conducting plates which may be two sheets of tinfoil, separated by a sheet of non-conducting material, such as mica or paraffined paper. The condenser is marked *C* and the key *K*. The intra-electrodal mode of stimulation is shown by diagram *a*, and the indirect extra electrodal mode of stimulation by the diagram *b*. About two volts, charging 0.5 microfarad, is, in general, found to be sufficient. When the key *K* is pressed down the condenser is charged, the instantaneous charging current passing in one direction. The upper arrow in this figure shows the direction of this charging current. When the key is released it springs back and discharges the condenser. The instantaneous discharge current now flows in a reverse direction. In Fig. 16 an arrangement for applying single make or break shock currents is illustrated, *K* being the key in the primary circuit, and the secondary circuit being capable of being short-circuited also by the second key.

Studied with the aid of the resonant recorder, different plants exhibit different characteristics of response. In studying the excitatory reactions of the plant under external stimulus it is first necessary to determine what time elapses between the incidence of the shock and the initiation of a perceptive responsive movement. This constitutes the determination of what is known as the "latent period." It is also desirable to ascertain at what rate this responsive movement of the leaf takes place and after what time the contractile phase of the movement is exhausted. After a short pause the plant gradually recovers from the effect of the shock and the leaf is re-erected to its former position. Hence, we would wish to know the various rates at which recovery gradually takes place.

Different plants exhibit different characteristics of response, Prof. Bose finds. The reactions are relatively quick in some and slow in others. In a typical case of Mimosa, in summer the latent period was one tenth of a second. The maximum fall of the leaf was attained in three seconds and the recovery completed in fifteen minutes. After the lapse of the latent period the leaf begins to fall, at first with increasing rapidity, which then again diminishes until it comes to a stop. The curve described attained a maximum amplitude, corresponding with the maximum fall of the leaf. The period required up to this point, Prof. Bose calls the "apex time." The rate of recovery in Mimosa is very rapid at the beginning and very slow toward the end. The maximum rate of recovery was 0.09 millimeter per second, in contrast with the maximum rate of fall of 24 millimeters per second. The movement of recovery is about three hundred times slower than the movement of excitatory fall. As the intensity of stimulus increases, the extent of responsive fall in Mimosa increases. Stronger stimulus and higher temperature have also a marked effect on the rate of movement; moreover, the rate of movement is decreased under fatigue. It is curious that a stronger stimulus, generally speaking, requires a longer period for recovery. Under the physiological depression induced by winter, the responsive reactions are modified, the latent period is prolonged and the amplitude reduced.

If, instead of giving the full period of rest necessary for complete protoplasmic recovery, the period of rest is shortened, a diminution in the height of response indicative of fatigue is noted in the record. This quite agrees with the exhibition of fatigue to be seen in muscle records in the same circumstances of diminished interval of rest. If a sub-tonic specimen be tested for fatigue, successive responses are found to undergo a gradual enhancement, or what is known in muscle response—with which it is exactly parallel, as a staircase increase shown in Figs. 7 and 7a. When deprived of the invigorating influence of favorable surroundings a plant becomes sub-tonic.

Under the action of successive stimuli the tonic condition is improved The loss of tone, with its consequent relaxation, will gradually give place to a better tone with increasing tonic contraction. Hence, the gradual bettering of tonic condition under successive stimulations may often find two simultaneous expressions. In the first place, the growing tone with its increasing normal tonic contraction will be seen in the shifting of the base line upward. Secondly, it will be exhibited in the growing amplitude of successive responses. Thus are to be explained the very remarkable records shown in Figs. 7 and 7a.

In order to demonstrate the variation of excitability induced by sudden diminution of light, Prof. Bose takes a set of three normal responses in diffuse daylight. The chamber in which the plant is confined is then suddenly darkened by means of an opaque screen. It will be noticed in Fig. 8 that the next two responses are nearly abolished; the excitability of the plant was, however, beginning to be restored after forty-five minutes' exposure to darkness. After an hour in darkness the excitability was fully restored, the response here being even larger than in light.

Prof. Bose noticed in Mimosa a depression of excitability on rainy days. This effect he was afterwards able to trace to the absorption of water by the pulvinus. The variation of motile excitability by absorption of water is very clearly exhibited in Fig. 6. A pair of normal uniform responses were first taken. A drop of water was then applied on the pulvinus, when the leaf was recovering from the second stimulus. The period of recovery was obviously very much protracted in consequence of absorption of water. The usual time for complete recovery is about fifteen minutes. In this case it was prolonged to forty-five minutes. The plant was obviously gorged and inactive as a consequence.

The effect of various gases upon plants has been studied with the greatest care by Prof. Bose. Ozone stimulates; carbonic acid gas, undiluted, depresses. The vapor of alcohol produces intoxication, which is quite apparent in the record, as shown in Fig. 4. Moreover, the continued action of alcohol vapor induces depression.

That a plant may be killed as well as an animal every one of us knows. But when does it actually expire? Plants that have been dead for hours are to the eye as fresh as if they were alive. One method by which the occurrence of death may be determined, Prof. Bose finds, is the abolition of that electric response which is characteristic of the living condition. A plant, as long as it is alive, gives in answer to a stimulus a galvanometric response. On the occurrence of death this particular response disappears. He finds that the electric response is abolished when the plant has been subjected for a time to a temperature of about 60 deg. Cent. The plant is placed in a water bath and the temperature of the bath is continuously raised by the application of a gas or spirit flame, very gradually of course, so that there may be no sudden variation or sudden excitation. In Fig. 15, the record was commenced at 25 deg. Cent., and the successive dots in the record are at intervals of 1 deg. Cent. The down curve indicates the expansive erection of the leaf. As soon as the temperature had reached 60 deg Cent there was an abrupt inversion and the spasmodic contractions took place at a very rapid rate. The successive dots in the upper portion of the curve are at intervals of 0.2 of a degree. The point of inversion indicates the death point, and the curve giving the death record may be regarded as the death curve. All attempts to stimulate a plant and to receive a response fail after the death curve has once been recorded. It is obvious, therefore, that the plant is really dead. At 60 deg. Cent. the last response given by plants invariably seems to occur. In taking an electrical record, it is found that an electric spasm also takes place at the critical temperature, which is very near 60 deg. Cent. The death point of the plant, moreover, is found to be lowered under physiological depression. Thus, under fatigue induced by tetanizing electric shocks, the death point is lowered from the normal 60 deg. Cent. to 37 deg. Cent. Poisonous re-agents also lower the death point. In a particular case Prof. Bose found that a poisonous solution of copper sulphate lowered the death point by 18 deg. Cent.

If a plant is thus responsive to external influences, if, in a word, it is sensitive in a very real sense, we may well ask whether there is a transmission of a true

excitatory change in the plant, and if so, whether there is in it any specific conducting tissue corresponding with the nerve of the animal for the conveyance of excitations. It is known that the excitation of a living tissue is attended by a concomitant electric change of galvanometric negativity. If we make suitable galvanometric electric connections with two points on a nerve, and we stimulate the nerve at a distant point, we shall find that the arrival of excitation from the distant stimulated point is, at a proper moment, signalized in the galvanometer by a deflection of a definite sign. Similarly, Prof. Bose has found that the excitatory change of galvanometric negativity is transmitted through a distance to certain plant organs. Tissues containing fibro-vascular elements, such as stems and petioles, are found to be good conductors of excitations. Indifferent tissues in leaves and tubers possess little power of conduction; in such cases excitation remains more or less localized. By applying stimuli of constant intensity and by allowing proper intervals of rest, successive values of velocity of transmission of excitation are obtained which are constant. Automatic records have been obtained showing a time interval as short as 0.05 second. The highest velocity of transmission of excitation Prof. Bose found in the petiole of Mimosa to be 30 millimeters per second. Prof. Bose has been able to show that excitatory reaction is initiated in the petiole of various sensitive plants by the discriminative polar action of an electric current. Excitation is induced at the cathodic point at make and at the anodic point at break. Transmission of such an excitatory impulse takes place in the absence of all mechanical disturbances. Freeze the plant or apply cold locally, and the conducting power is abolished. Poison the plant locally and conductivity is again destroyed. It is evident that excitatory impulses are conducted in plants quite as they are in animals.

In certain plants, such as the telegraph plant of India, spontaneous movements of a rhythmic character may be observed. A very remarkable study of this plant which Prof. Bose carried out shows that these rhythmic pulsations of the telegraph plant leaflets may be correctly likened to the pulsations of animal heart tissue. Because a large plant cannot easily be manipulated, Prof. Bose experiments with the detached petiole carrying the pulsating leaflet. As in the case of the isolated heart in a state of standstill, the movement of the leaflet can be renewed in the detached specimen by the application of internal hydro-static pressure. Under these conditions the rhythmic pulsations are easily maintained uniform for many hours (Fig. 10). As shown in Fig. 14, the petiole after detachment is put in water and mounted watertight, in the shorter open end of a narrow U-tube filled with water. The longer end of the U-tube consists partly of India rubber tubing. By raising or lowering this longer limb of the U-tube, the hydrostatic pressure to which the specimen is being subjected can be varied; different chemical solutions can also be applied internally by its means; a stop-cock allows the water to run out of the U-tube, making way for the particular solution poured in at the open end of the tube. The resonant recorder shown in Fig. 2 would not be able to trace records of the smallest movements of the leaflet. The leaflets have a pull which is so very feeble that the inertia of writer cannot be overcome. As the pull exerted by the leaflets is very feeble, the writer must be made extremely light. The oscillating recorder has been devised for this purpose; an instrument in which the recording plate, by means of an electric motor provided with an eccentric, is made to execute a reciprocating movement. The intermittent dots thus produced may be one in each second or one in two seconds. As the oscillating recorder permits the employment of a light grass haulm for the recorder, a fair magnification in the record may be obtained. Prof. Bose has used both methods, resonant and oscillating, for obtaining the records. In the former they appear continuous; in the latter dotted. But when it is desirable to obtain data for accurate time measurements of different plastic movements of the leaflet the oscillating recorder is employed.

As an example of the extreme regularity which can be secured in the pulsating movements of such specimens, the record shown in Fig. 10 may be studied with interest. This is a continuous record lasting for four hours, the movements themselves being maintained uniform for more than seven hours. The run of the breadth of the plate was accomplished in one hour and twenty minutes, successive series of records being taken on the same plate from below to above. Prof. Bose found that the application of shock to a leaflet in a state of standstill induces a down movement. The phase of the down movement is, in general, quicker. Enforced expansion by increased internal hydrostatic pressure induces movement of the leaf upward. In a typical example of the rhythmic pulsation of the telegraph plant, the leaflet accomplished its down movement in 41 seconds. The maximum rate of down movement is 0.9 millimeter per second, the average rate being 0.44 millimeter per second. The period of up movement is longer, being 60 seconds. The maximum rate of up movement is 0.56 millimeter per second, the average rate being 0.3 millimeter per second. In the rhythmic pulsation of a frog's heart variation of temperature changes the period and modifies the amplitude of pulsation. Prof. Bose has been able to prove that the lowering of temperature has on the telegraph plant precisely the same effect. The rhythmic pulsation of the cardiac tissue is arrested when subjected to a certain low temperature. Similarly, the pulsation of the telegraph plant is arrested at a sufficiently low temperature. The critical point is somewhat modified by the condition of the specimen. With vigorous specimens the temperature at which arrest takes place may be as low as 17 deg. Cent. The converse is also true. Increase the temperature and the pulsations of the telegraph plant will become more marked. Alcohol has a marked action upon the heart. What is its effect upon the telegraph plant's leaflets? Prof. Bose found that strong alcohol solutions induce a depression which may permanently arrest the pulsation, exactly as in the case of cardiac tissue. The effect of carbonic acid gas is shown in Fig. 9. Diluted with air, this gas causes an enhancement of amplitude, though the period becomes longer. Fresh air produces a revival of normal pulsation. Ether produces at first a transient exaltation, followed by depression and arrest of pulsation. More pronounced is the effect of chloroform, which is far more toxic in its action. Carbon disulphide arrests the pulsating activity of the plant. Copper sulphate also produces an arrest of pulsation. So powerful is the poisonous effect of potassium cyanide solution that rhythmic activity of the telegraph plant is very quickly abolished. The effect of acids and alkalis on the rhythmic movements of the telegraph plant are, as on the animal heart, antagonistic.

What Happens When Gunpowder Explodes*

The basis of modern smokeless powder is guncotton, to which a great variety of forms can be given, but the efficiency of the explosive is greatly increased by an admixture of nitroglycerine. To synthetic chemistry we owe both smokeless powder and the high explosives which are used for filling shells and bombs. Picric acid was first employed for this purpose, instead of black gunpowder, about 30 years ago, but for the last 10 years picric acid has been superseded by trinitrotoluol, which satisfies the requirements better than any other known explosive.

The explosion of a charge of powder in a rifle or a cannon is designed to impel the projectile forward with gradually increasing velocity, without endangering the integrity of the gun by excessive gas pressure. The charge of a shell, on the other hand, is designed to shatter and destroy by generating the maximum pressure in the shortest possible time.

The pressure caused by explosion depends, in the first place, on the quantity of gas generated, which can be measured by exploding a small known quantity of the powder in a very strong, thick-walled shell, connected with a gasometer. In this way it is found that black gunpowder produces 290, guncotton 950, and trinitrotoluol 970 liters of gas, per kilogramme of explosive, the gas being measured at atmospheric pressure (760 millimeters) and at 0 deg. Cent.

The pressures developed in large artillery guns are very great, varying from 2,000 to 3,000 atmospheres. In order to withstand these enormous pressures the guns are made of nickel-steel, chromo-steel and other improved steels, some of which are so strong that they resist even the premature explosion of a shell in the gun. The improvement that has been made in gun material is shown in the following table in which "tensile strength" is the weight, in kilogrammes, required to pull asunder a bar one centimeter square; "elastic limit" is the weight required to produce permanent increase in length, and "extensibility" is the percentage of the original length by which the bar is stretched at the instant of rupture. The extensibility furnishes a measure of the toughness of the material.

	Tensile strength.	Elastic limit.	Extensibility.
Cast iron	2,340	1,110	0.4
Common steel . . .	4,200	2,440	11.5
Nickel steel	7,500	4,400	18.0

Special construction, as well as strong materials, are required to withstand the pressures developed by modern explosives. A cannon is now always composed of several parts, so arranged that the outer parts exert pressure upon the inner parts even when the gun is not in use. This principle has led to the construction of mantled and ringed guns in Germany, and of wire-wound guns in England.

Gun-makers have devoted much attention to the problem of making the powder chamber gas-tight. With cartridge ammunition the brass shell of the cartridge furnishes the required closure behind. In guns of larger caliber the same result is accomplished by means of packing rings of soft copper. In front, gas-tight closure is effected by the projectile which is pressed tightly into the rifling.

The explosion of the projectile is accompanied by a reaction, called the recoil, which impels the gun backward. Even in field pieces the force of the recoil may amount to 100 tons, and it is proportionately greater in large naval and siege guns. This tremendous shock must, of course, be taken up by the mounting of the gun.

The rate at which the gas pressure is developed is as important as its maximum value. It has not been found possible to measure directly the variations of pressure during the discharge, but they have been determined indirectly by recording the passage of the projectile through the bore. The gas pressures can be deduced from the measured velocities of the projectile in the bore.

The ideal condition would be constant pressure from the start of the projectile to its emergence from the muzzle, but this condition cannot be realized. The pressure increases as long as the effect of the liberation of fresh gas exceeds the effect of the space added by the advance of the projectile. The pressure diminishes from this point, and drops suddenly to atmospheric pressure when the projectile leaves the gun. The velocity of the projectile varies in a similar manner, attaining a maximum value at a certain point, and diminishing somewhat toward the muzzle.

The energy of an explosive is determined by the heat produced by its explosion, or combustion. Only 10 to 35 per cent of this energy is transformed into the kinetic energy of the projectile, the rest being consumed in overcoming friction, heating and expelling the gases, producing the recoil of the gun, etc.

The heat of combustion of an explosive is measured by exploding a small quantity in a strong shell immersed in a water calorimeter with a delicate thermometer. In this way it is found that black gunpowder produces 750, guncotton powder 940, nitroglycerine powder 1,330, and trinitrotoluol 720 calories per kilogramme of explosive, a calorie being the quantity of heat required to raise the temperature of one kilogramme of water 1 deg. Cent. These values are much lower than those obtained with many non-explosive combustibles, but the rapidity of explosive combustion produces very high temperatures. The temperature of explosion has never been measured directly but it can be calculated approximately from the heat of combustion of the explosive and the specific heat of the gases produced. Thus the explosion temperature of a powder used in infantry rifles in Germany is estimated at 2,100 deg. Cent. These high temperatures greatly increase the gas pressure and the velocity of the projectile, but they also shorten the useful life of the gun.

The velocity with which ignition progresses in explosives is astonishingly great. In picric acid it is 8,000 meters (about 5 miles) per second. Loose guncotton is completely consumed in 0.0004 second, black gunpowder in 0.0015 second when finely pulverized, 0.0057 second when in granular form, and 0.0084 second when strongly compressed. Hence it appears that the velocity of ignition is affected by the density of the explosive and is greatly diminished by compression. The velocity of ignition depends also on the space available for the explosion. The explosion of a heavy charge in a very small space produces intense pressure, which accelerates the combustion. In modern practice the charge of smokeless powder which is used about half fills the powder chamber.

Accurate knowledge of the ignition velocity is necessary in order to determine the efficiency of a powder. The ideal powder would be completely consumed exactly at the instant when the projectile emerges from the gun. This condition is not attained in practice. A flame which indicates unfinished combustion always issues from the mouth of the gun. In some conditions, this flame may go far toward counterbalancing the advantages of smokeless powder.

Explosives differ very greatly in sensitiveness, or liability to explosion by mechanical shock. The sensitiveness is measured by letting a weight fall on the explosive from a height which is gradually increased until explosion occurs. The height through which a weight of 2 kilogrammes must fall in order to produce explosion is 1 centimeter for fulminate of silver, 25 centimeters for picric acid, and 108 centimeters for trinitrotoluol. This shows the superiority of trinitrotoluol to picric acid in in point of safety. The excessively sensitive fulminate is used only as a primer.

* Adapted from *Naturwissenschaftliche Wochenschrift*, as quoted in *Die Umschau*.

The Gatun Dam*

By C. D. Ward, M. Am. Soc. C. E.

In a paper,[1] entitled "Inter Oceanic Canal Projects," by A. G. Menocal, M. Am. Soc. C. E., it is stated that the Government Commission, appointed in 1875, reported, as to a canal with locks, from Colon to Panama, as follows:

"The river (Chagres) is proposed to be crossed by means of an aqueduct having twelve spans of 90 feet each, 1,900 feet extreme length, 65 feet wide, and 26 feet deep."

In discussing this paper,[2] the late Ashbel Welch, past president, Am. Soc. C. E., a thorough and noted canal engineer in his day, said:

"The first thought of an American canal and river engineer, on looking at M. de Lesseps's raised map is to convert the valley of the lower Chagres into an artificial lake, some twenty miles long, by a dam across the valley at or near the point where the proposed canal strikes it a few miles from Colon, such as was advocated by Mr. C. D. Ward."

The site proposed for this dam was at Gatun, 7.5 miles from deep water at Colon, the end of the canal. But as is well known, the use of locks was not to be thought of under M. de Lesseps domination, and a sea level canal was commenced in 1883.

In 1887 it was at last decided that locks would have to be used, and from that time to the present, various locations and elevations for the necessary locks have been suggested and different sites for the great dam selected.

The New Panama Canal Company and the Isthmian Canal Commission of 1899, the latest authorities, agree in locating the dam near Bohio, 16.5 miles from deep water at Colon, or 9 miles farther up stream than Gatun, the location suggested by Mr. Welch in 1880.

Furthermore, the Isthmian Canal Commission says in its report that "no location suitable for a dam exists on the Chagres River below Bohio."[3]

The late George S. Morison, past president, Am. Soc. C. E., a member of the Isthmian Canal Commission, commenced his paper on the Bohio dam which was presented to this society on March 5th, 1902,[4] with this sentence:

"All engineers who have examined the route of the Panama Canal agree that the neighborhood of Bohio is the only available location for the dam by which the summit level must be maintained."

Neither of these authorities mentions or gives any consideration to the project of a dam at Gatun, nor even condemns it, nor is the writer aware that any soundings or other examinations looking to a dam at this point have ever been made.

As this question may be worthy of more consideration than it seems to have received, some of its advantages may be stated. The canal as proposed by the latest authority, the Isthmian Canal Commission, may be briefly described as follows: From deep water in Colon harbor to the Bohio locks the Atlantic maritime level cut mostly through the low flat valley of the Chagres will be 16.81 miles long. The two Bohio locks with a lift of 45 feet each reach the Bohio lake formed by the Bohio dam with a maximum elevation of 90 feet above tide in Colon harbor and an area of 38.5 square miles. The summit level thus attained extends through the Culebra cut. The distance from the Bohio locks to the Culebra cut is 13.61 miles and from thence through the Culebra cut to the Pedro Miguel locks at the farther end of the level the distance is 7.91 miles. The maximum combined fall of these two locks is 62 feet. From Pedro Miguel locks a level of 1.38 miles extends to Miraflores lock which has a maximum fall of 38 feet to mean low tide in Panama harbor. For a distance of 4.12 miles beyond this lock the canal extends through the low swampy country in which the Rio Grande flows to a point known as La Boca on the edge of Panama Bay. A dredged channel extends from this point 4.41 miles to the 6 fathom line in Panama Bay.

Allowing 0.90 mile for the various locks the total length of the canal is 49.09 miles.

As to the suggested dam at Gatun, the New Panama Canal Company has made a contour map of the region where the dam would probably be located, if at all. If a dam were built here, impounding the water to an elevation of 90 feet, then, of course, the Bohio dam and the locks and spillway would be omitted, and locks would be built at Gatun.

The length of the dam would be 6,750 feet, while the length of the Bohio dam is 2,546 feet. The area of the section is nearly three times that at Bohio, therefore it might not be out of the way, for the present, to say that the cost of the Gatun dam would possibly be three times that estimated for the Bohio dam, or $19,108,920. At present, there seems to be no reason to think that the locks would cost more at one place than at the other, but the spillway should be somewhat longer and might cost more. There may be a question whether the hills to the west of Gatun are high enough to contain the Gatun lake at an elevation of 90 feet, but the raised map made by the New Panama Canal Company, a reproduction of which is to be seen at Columbia University, indicates sufficiently high ground. The lake would extend far up the valley of the Rio Gatun on the east and the Rio Trinidad on the west, and submerge the Chagres Valley for 9 miles, including the Aqua Clara, Pena Blanca, Vino Tinto and Bruja Swamps, cover 20 or 30 square miles of swampy land and thus improve the healthfulness of the country. This lake area added to the 38.5 square miles of the Bohio lake would be a benefit in every way and would render the Alhajuela dam on the Upper Chagres unnecessary. Between Gatun and Bohio the excavation of the sea level canal, the Pena Blanca swamp outlet to Aqua Clara swamp, the Chagres diversion from Aqua Clara swamp to near Gatun and the diversion of the Rio Gatun would become unnecessary and their cost would be saved. These items amount to $14,635,604, a sum large enough to pay the assumed extra cost of the Gatun dam and leave about $2,000,000 to pay for changing the line of the Panama Railroad and the possible additional cost of the spillway. If these assumptions should prove practicable the result would be a better and safer canal, shorter time of transit and more healthy conditions, all at no greater cost and with lower maintenance charges.

* This paper was presented at the meeting of the American Society of Civil Engineers May 18th, 1904. It is reproduced here for the purpose of showing that in 1904, or one year before the Board of Consulting Engineers appointed by President Roosevelt adopted the plan for a lock canal, Mr. Ward had formally advocated the construction of the dam at Gatun. Colonel G. W. Goethals in a letter to Mr. Ward wrote in 1907: "The service you rendered in calling attention to the feasibility of the Gatun Dam in a paper presented to the American Society of Civil Engineers is recognized by the Engineering Committee." Editorial discussion of this paper will be found in the current issue of the SCIENTIFIC AMERICAN.

[1] *Transactions* Am. Soc. C. E., 1879, vol. viii, p. 311.

[2] *Transactions* Am. Soc. C. E., 1880, vol. ix, p. 148.

[3] Report of the Isthmian Canal Commission, 1899-1901, p. 90.

[4] *Transactions* Am. Soc. C. E., vol. xlviii, p. 235.

Printing for the Blind

One of the noblest works of man has been his efforts to lead his blind brother, and especially to enable him to read by his sense of touch. A number of publications for the blind are shown in an exhibit of the Graphic Arts division of the U. S. National Museum in the Smithsonian building. The first efforts in this connection are credited to a Spaniard named Francesco Lucas, who planned the engraving of letters on blocks in the sixteenth century. His scheme was followed in 1640 by a system of cast lead letters planned by Pierre Moreau of Paris, who unfortunately had not the means to carry out his idea. There followed systems of different sorts: pins set in cushions, wooden letters, the movable metal letters of Du Puiseaux, the letters cut in cardboard, and pricked maps made by R. Wiessem bourg, a German, with which he succeeded in teaching Mlle. Paradis, a talented musician.

The honor of being the first to introduce printing for the blind in raised characters like embossing is attributed to Abbe Valentin Hauy of Paris, who effected his plan in 1784, the result of his accidentally discovering that his blind pupil could read parts of a printed card heavily indented by the types. Relief printing was the result.

James Gall of Edinburgh embossed several elementary works and was the first to conceive the idea of printing the Bible for the blind; he completed the Gospel of St. John in 1834. His system employed the common English letter but replaced the curves by angles. Printing for the blind was commenced in the United States in 1833 at Boston and Philadelphia. Improvements were made by Friedlander, Lucas, Wait, Frere, Howe, and Kneass. Dr. S. G. Howe of Boston established a system in which he used the lower case English letter without capitals, and like Gall with angles instead of curves. In this manner he printed the entire New Testament in 1838 and completed the Bible in 1843.

A method clearly meant for adults and persons whose fingers are not as sensitive as those of youth was effected by Dr. William Moon of England in 1847. This preserved part of the outline of the Roman letters, but was nevertheless one of the arbitrary systems and is too unwieldy for general use. One feature of this style is the guide for the reader's finger at the end of the lines; the even numbered lines are read from right to left.

The arbitrary point system was invented early in the nineteenth century by Capt. Charles Barbier, a French officer, who substituted embossed dots for lines. This was arranged in its present form by Louis Braille, a pupil who afterward became a professor in an institution for the blind in Paris. As it is used to-day this system comprises combinations of six dots arranged in two vertical lines of three each, making possible sixty-three different combinations. 'A' is represented by

and 'T' by while stands for and

Naturally the alphabetical systems are of advantage over those of an arbitrary nature since they may be read by seeing persons with ease, enabling anyone to read or teach from such books, while a special teacher is required to instruct in the others.

The first books for the blind were very bulky, and many attempted to decrease their size and consequently the cost. They are still voluminous, however, three more volumes than are required for an ordinary encyclopedia being required to complete Defoe's Robinson Crusoe. One of the several books to be seen in the collections in the Smithsonian building is a bulky volume of this work.

The chief American systems are: J. R. Friedlander's Roman capitals, in which has been printed the only dictionary for the blind; Howe's angular lower case letters; the French alphabet with capitals and rounded lower case letters; and Kneass's improved system combining capitals and angular lower case letters, the lower case letters with tails being raised so that no part extended below the line. The last style was the innovation of a blind writer, N. B. Kneass, Jr., who also established a magazine for the blind in 1867.

The Graphic Arts exhibit contains samples of the Kneass system and a copy of his Philadelphia *Magazine for the Blind*. Publications of the Howe Memorial Press of Boston, the American Printing House for the Blind of Louisville, and specimens of the Moon and Braille systems are also shown, together with relief maps and illustrations.

Electrolytic Iron Melted in Vacuo

At a meeting of the Urbana Section of the American Institute of Electrical Engineers an interesting paper was read by Trygve D. Yensen on the above subject. The following abstract of the author's remarks is derived from the *Proceedings* of the Institute in which the paper was published.

Electrolytic iron of a purity of 99.97 to 99.98 per cent was melted in fused magnesia crucibles in a modified Arsem furnace, forged into rods, machined and annealed in an electric furnace according to various heat cycles.

The magnetic properties were obtained by the Burrows double bar method. Determinations were also made of the electrical resistance, chemical composition and physical properties, including microstructure and critical temperatures, as well as tensile tests. A few commercial iron and steel samples were tested for comparison.

The following valuable results were obtained:

1. Pure iron melted in an atmosphere of carbon monoxide under atmospheric pressure will absorb both carbon and oxygen, with the result that the iron thus produced is of an inferior magnetic quality.

2. Low carbon iron melted *in vacuo* will lose 50 to 90 per cent of its original carbon content.

3. The magnetic quality of electrolytic iron melted *in vacuo* is decidedly superior to any grade of iron thus far produced, the maximum permeability obtained being 19,000 at a flux density of 9,500 gausses. The average hysteresis loss obtained is less than 50 per cent of that found in the best grade of commercial transformer steel, due to the fact that the coercive force is very much lower than for silicon steel, although the retentivity is higher.

4. The specific electrical resistance of pure iron melted *in vacuo* is 9.96 microhms per centimeter cube.

5. Swedish charcoal iron melted *in vacuo* has a magnetic quality approximating that of electrolytic iron melted *in vacuo*, chiefly due to the reduction of the carbon content.

The author suggests that the high electrical conductivity and hence large eddy current losses in this material may possibly be greatly reduced by the addition of silicon or aluminium without very materially affecting the magnetic quality.

A cement for fastening metal to metal is given in the *American Machinist*. It consists of thirty parts plaster of paris, ten parts of iron filings, and half a part of sal ammoniac. These materials are mixed and acetic acid added to make a thin paste, which must be used immediately.

A South American jungle along the Paraguay.

The Roosevelt-Rondon Scientific Expedition—I*

Its Movements in South America and Some of Its Zoological Achievements.

By L. E. Miller, Mammalogist of the Expedition

THE plan of the expedition, fully decided upon after consultation with the Brazilian government on arrival at Rio de Janeiro, took shape as follows: to ascend the Paraguay to the highest navigable point, cross the vast breadth of Matto Grosso on mule-back and descend the unexplored Rio de Dúvida. It was decided also that the main purpose of the expedition should be an exploration of the Rio da Dúvida with zoological collecting as we moved along or as opportunity presented itself.

The steamship "Vandyck" remained at anchorage in the harbor of Rio de Janeiro two days, which gave us ample time to view the natural scenic wonders of the harbor, and the beautiful city. The greater part of one day was spent in the botanical gardens which with the avenues of stately royal palms and large collections of plants from all parts of the tropical world, doubtless surpass anything of a similar nature found in South America. Here Colonel Roosevelt left the party, accompanied by his son Kermit and Doctor Zahm; the remainder of the expedition consisting of Mr. George K. Cherrie, Mr. Jacob Sigg, Mr. Anthony Fiala and myself, resumed the voyage and reached Buenos Aires six days later (October 27th), 23 days after leaving New York. We had stopped a day at Santos, Brazil's great coffee center, and another at Montevideo, the capital of Uruguay.

Mr. Cherrie and the writer were eager to devote every available moment to the zoological work, so leaving Messrs. Fiala and Sigg, whose duty it was to look after the handling of the large amount of impediments, we secured passage on the Argentine Northeastern Railroad, which had just inaugurated through service to Asuncion, Paraguay. We took only the small amount of equipment necessary for a few weeks' work as the two others were to come up with the remainder of our luggage via the first available freight boat. Our train was the second to make the through trip, and was scheduled to run bi-weekly. It was composed of seven Pullmans, two baggage cars and a dining car, and the service was good. Leaving Buenos Aires on the afternoon of Sunday, November 2d, we reached Rosario at about dark. Here the train was run on to a steel boat and carried up river for about 4 hours, after which it continued the journey on the east bank of the Paraná. The next night we recrossed the river on a ferry boat and were landed at Encarnacion, Paraguay. Asuncion was reached late in the afternoon of Tuesday.

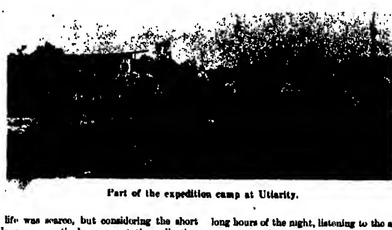
The railway journey had been through level plains country, interspersed at long intervals with small clumps and strips of low woods; but it is essentially a grazing country, and we passed numerous herds of cattle contentedly grazing in the vast, fence-inclosed ranges. Stalking calmly among the herds were small bands of rheas, semi-domesticated, but they were not abundant. I doubt if we saw thirty during the entire trip. Caracaras,[1] glossy ibises, jacanas,[2] rails and spur-winged plovers, were numerous along the line, and frequently we saw the domed mud-nests of the oven-bird perched upon fence posts or lower branches of trees. Villages are few and far between, and the natives, a motley crowd of dark-skinned individuals, usually left their shambling, grass-thatched huts and came down *en masse* to see the train.

After spending a few days at Asuncion, we were invited to the home of Prof. Fiebrig, who lives at Trinidad, a short distance away. Prof. Fiebrig is a scientist of more than local note, an instructor in the University of Paraguay and curator of the museum. Our first zoological work was done on his estate. All about were tracts of low forest of considerable size, patches of brush country, grassy fields and cultivated plots. Birds were very abundant, and as practically everything was new to us, our work was doubly interesting. We here formed our first intimate acquaintance with the peculiar white ani[3] (*Guira*), large flocks of which were in the palm trees. The birds sat soberly on their perches, awkwardly jerked their tails from side to side and mewed dolefully. They seemed to be utterly out of place among the vivacious tanagers, creepers and finches, and to belong more properly to the fauna of some remote and unrecorded past. Mammalian life was scarce, but considering the short time available, a comparatively representative collection was made, including a series of a small rare wolf (*Canis*).

Through the courtesy of the president of the republic, a launch was placed at our disposal, and on November 11th we started on a short voyage up the Rio Pilcomayo into the Grand Chaco of Paraguay. We reached a small settlement called Porto Galileo that night, where we were the guests of the "Quebracho" Company. A large mill had been erected for the extraction of tannin from logs brought in from the surrounding country, and a narrow-gage railway was being constructed in the interior, a distance of 60 kilometers, 15 kilometers of which was already in operation. We proceeded to the end of the line and pitched camp on the bank of a small stream, the Rio Negro, infested with piranhas, the little man-eating fish, no larger than a trout that kills swimmers.

Our camp was merely a rough shed built of sheets of corrugated iron supported on poles driven into the ground. The river water was salt and unfit for use, so each morning several large jugs of drinking water were sent us from Porto Galileo, together with a supply of fresh provisions. All about lay marshes, swamps and large grass-covered areas, the latter type of country predominating.

It is in the dark swamps that the precious quebracho trees grow. It was also from these same swamps that clouds of ravenous mosquitoes issued with the first signs of failing daylight, and drove us to the refuge of our net-covered hammocks. There we sweltered through the long hours of the night, listening to the angry buzzing of our outwitted assailants, which was not unlike the sound produced by a swarm of enraged bees. I could distinguish a number of different pitches and qualities in the music, blending harmoniously in one general chorus. The varying size of the insects, which ranged from individuals nearly an inch long to small, infection-bearing



Part of the expedition camp at Utiarity.

* From the *American Museum Journal*.

[1] Caracara, a member of the hawk family.

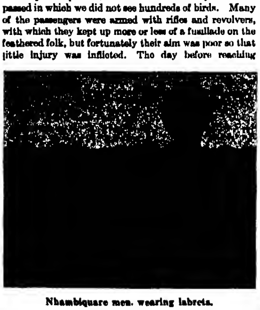
[2] Jacana, a bird that combines certain characteristics of both plover and rail.

[3] Member of a subfamily of the cuckoos.

Utiarity Falls, South America, two hundred and fifty feet high.

Anopheles, doubtless accounts for the different tones produced by the vibrations of the wings. Small brockets[6] were plentiful in the swamp and came out into the fields to feed morning and night, and in the tall grass, cavies[1] abounded. Ocelots had worn well-defined paths through the fields in their nightly raids on the cavy community. In the trees we found black howlers, night monkeys and tayras[8]; on the ground, opossums and various small rodents held sway. When time permitted us to take a few moments' recreation, we fished for piranhas[7] in the stream, the ravenous creatures throwing each other clear of the water in their frantic struggles to get at the meat bait.

After a profitable week's work on the Pilcomayo we returned to Asuncion, where we were joined by the two commissaries who had just arrived with the equipment. Two days later we boarded the comfortable little steamer "Asuncion" and sailed for Corumbá. The four and a half days' trip on the Paraguay was most interesting, although the heat was intense and insects at times were troublesome. We had entered the great *pantanal* country, and the vast marshes teemed with bird life. As the "Asuncion" plowed her way through the water, countless thousands of cormorants and anhingas[8] took wing; lining the pools and dotting the marshes were hordes of wood and scarlet ibises, together with herons and a sprinkling of spoonbills; egrets covered the small clump of trees as with a mantle of snowy white, and long lines of jabirus patrolled both shores. Scarcely a moment passed in which we did not see hundreds of birds. Many of the passengers were armed with rifles and revolvers, with which they kept up more or less of a fusillade on the feathered folk, but fortunately their aim was poor so that little injury was inflicted. The day before reaching



Nhambiquare men, wearing labrets.

Corumbá we passed an interesting old land-mark, the fort of Coimbra, built on a rocky hillside with a cluster of thatch-roofed huts nestling against the base. It is near the Bolivian border and in by-gone years figured prominently in several of the bloody controversies between the neighboring republics.

Having heard of a place called Urucúm, but a short distance away, which seemed to offer unusual opportunities for collecting, Mr. Cherrie and the writer immediately moved to that place and established headquarters. Urucúm proved to be a garden spot of clear, cold springs, shady groves, and plantations of tropical fruits and vegetables. Easy of access were fields, forested hillsides, marshes and lagoons in which dwelt an abundant and varied fauna. Swarms of bats of several species inhabited the mango trees as well as the culverts and manganese mines in the hillsides, and furnished an unfailing supply of material; squirrels, coatimondis,[9] monkeys and marmosets lived in the trees; on the forest floor ranged agoutis,[10] deer and peccaries. Traps left overnight, caught wooly opossums (*Metachirus*), small rodents and giant black lizards that fought viciously when we sought to release them. One of the mammals added to the collection at Urucúm was of unusual interest; it was the formidable *guaraguazú*, a yellow wolf which equals or exceeds in size, the great gray wolf of our own north woods; it is an animal of solitary habits and is so rare that it is seldom met with. It was not previously represented in the American Museum's collection. From the hosts of birds we secured pigmy owls, tinamous, thrushes, grebes, rails and ant birds that were out of the ordinary. We spent nearly three weeks at Urucúm, and each day we added a number of species that were new to us. In the meantime, Colonel Roosevelt and his Brazilian escort had reached Corumbá, and a hunting trip on the Rio Taquary had been planned to secure specimens of the large game that is found in that region.

December 16th found the hunting party aboard the "Nyoac" steaming up the Taquary. This boat had been placed at the disposal of the expedition by the Brazilian government, and was our "home" during the weeks that followed, until we reached Porto Campo. Besides Colonel Roosevelt, there were on board, Colonel Candido Mariano da Silva Rondon, Mr. Kermit Roosevelt, Captain Amilcar de Magalhaes, Mr. Reis the photographer, a physician, a taxidermist and myself. Mr. Cherrie remained at Urucúm to finish the work in that locality, and the commissaries were detained in Corumbá. We reached the landing at the Estate Palmiras just at dusk and spent the night aboard, preparing the skin of a giant anteater which had been shot by Colonel Roosevelt near the river. Early next morning the party was in the saddle, galloping across the grassy marshes. Here and there small clumps of trees and thorny bushes dotted the marshes, and these were teeming with birds of many species: parrots, parrakeets and macaws flashed by with raucous shrieks, and flycatchers calmly surveyed the cavalcade from the uppermost branches. Occasionally we flushed a small flock of teals and, in the distance we saw ibises and jabirus standing in the long grass, like white specks in a sea of green. In spots the marshes were drying, the ground covered with fish; in the small pools an almost solid mass of fishes wriggled in the shallow water which had been churned into thin mud, and at the borders, numbers constantly leapt out; the ground was strewn with the dead and dying myriads of many species.

The ranch house or *fazenda* was reached at noon; it was an interesting place, the long, low rambling buildings forming a square with an open court in the center in which trees and flowers grew, and chickens and pigs roamed at will. All about lay marshes, papyrus swamps, fields and forests. Numerous herds of half-wild cattle grazed on this vast range, and in the papyrus thickets, marsh deer were not uncommon. The main object of this excursion, was the lordly jaguar and a magnificent pair were taken after several all-day hunts. Another giant anteater, several deer and a capybara[11] were collected; also a splendid series of the rare and beautiful hyacinthine macaw was added to our rapidly growing list of treasures.

Returning to Corumbá on the evening of December 24th, we were joined by the other members of the expedition and immediately proceeded on the up-river voyage toward São Luis de Cáceres. A short side trip was made up the Rio São Lourenço, with brief stops at various points where there were evidences of game; and numbers of birds, including screamers, penelopes,[12] parrots and various species of water-fowl were collected, also numbers of small rodents, monkeys, deer and peccaries. The jabiru storks were nesting on the São Lourenço, their great platform nests of sticks perched in the crotch of giant trees. The young storks, two in number and fully feathered, were continually exercising their limbs by running back and forth in the nest, flapping their wings all the while, preparatory to launching forth into the big world.

(*To be continued.*)

[6]Brocket: a small South American deer having unbranched horns.

[7]Cavy, a rodent of South America allied to the guinea pig and capybara.

[8]Tayra: a South American mammal resembling the weasels and martins.

[7]Piranha: the most ferocious small fish in the world, a deadly enemy of man, known as the cannibal fish. It is generally about 12 inches in length.

[8]Anhinga: the American snake-bird.

[9]Coatimondi: also *coatimundi* and more popularly known as *coati*. An American carnivorous quadruped, most nearly related to the raccoon, called also *tejon*.

[10]Agouti: a rodent about the size of the rabbit.

[11]Capybara: the largest existing rodent, resembling the guinea pig.

[12]Penelope: a small South and Central American bird, a small curassow, related to the guan.

Parecis babies at Utiarity.

Progress in Aeronautics*

A Review of Recent Air-raids and What They Have Accomplished

By Major H. Bannerman-Phillips

The first air-raid of any importance against Great Britain occurred in January, and so late in the month that it was impossible to do more than briefly allude to it in these notes, having regard to space available and the exigencies of getting them ready for publishing in time for the monthly issue of the magazine. A review of air-raids in general since the commencement of the present world-war shows that while this attempt of the enemy was apparently conceived on a more ambitious scale than any previous enterprises of a similar kind, the results were small in proportion to the scale of its conception. We may summarize the more important records as follows:

August 30th, 31st, September 1st, 2nd, and 3rd.—Daily visits to Paris by Taube aeroplanes.

September 1st. Zeppelin airship over Antwerp. Many bombs dropped. Other raids followed with considerable loss of life.

September 4th.—Commander Samson reported bombs dropped on four enemy officers and forty men near Dunkirk.

September 22nd.—Lieutenant Collet and other airmen dropped bombs on Zeppelin sheds at Düsseldorf. Serious damage was done: a distinctly successful raid.

October 8th. British air raid over Cologne and Düsseldorf, Zeppelin airships believed to have been destroyed (Lieutenant Marix).

October 11th.—Two German airmen visited Paris and dropped many bombs. Three killed, fourteen wounded.

November 22nd.—Raid on Zeppelin sheds at Friedrichshafen. Much damage done. Squadron-Commander Briggs forced to descend and taken prisoner injured. Results more commensurate with the efforts put forth by our airmen. Most successful.

December 5th.—Enemy aeroplane reported over Dover at 10:55 A. M., but went out to sea again.

December 8th.—French airmen dropped eighteen bombs on Freiburg. To judge from the enemy's published comments, this was most successful.

December 17th-18th.—French airmen dropped bombs on Saarburg, in Lorraine, throwing ten bombs.

December 24th.—German aeroplane flew over Dover and dropped bombs. No damage.

December 25th.—Great British air-raid on Cuxhaven. Commander Hewlett missing, but subsequently found safe. Reports from neutral sources tended to show that both moral and material effects were serious.

December 25th.—German air-raid on England. Bombs dropped near Chatham. Running fight down the Thames as raiders are chased away.

December 26th.—Zeppelin over Nancy at 5:20 A. M. Fourteen bombs dropped. Two people killed. Two injured. Damage to buildings.

December 30th. Great German raid on Dunkirk. Twenty killed; many injured.

January 3rd.—German newspapers claimed that their airmen dropped bombs on Dover.

January 6th.—Three Zeppelins reported off Calais; no apparent result.

January 10th.—Fifty bombs dropped by Germans on Dunkirk. Many killed and injured. The enemy considered this a distinct success.

The attempt by the enemy's airmen on December 25th appears to have been boldly conceived and carried out with considerable daring. Two airmen in a biplane were sighted on Christmas Day at 12.35 P. M. flying very high east to west over Sheerness. Immediately the enemy was seen anti-aircraft guns opened fire on the invader and three British biplanes went up and gave chase. Two British craft managed to fly above him and fired shot after shot. The fight continued over the Thames estuary to Southend, where there was only one British machine in pursuit. Finally, the German biplane evaded the pursuers and made off toward the sea.

From the fact that the body of a German airman was subsequently found in the Thames, it seems probable that the raiders never returned to report what they had seen or done, so that it is to be presumed that this attempt was a failure. Then came another raid on the night of January 19th-20th. This was directed against Yarmouth and other places on the east coast of England, and judging from the size of bombs found unexploded and other evidence—apart from published German reports, which are not necessarily accurate—was carried out by large naval Zeppelin airships, cigar-shaped craft about 520 feet in length and 50 feet in diameter with a capacity of 750,000 to 1,000,000 cubic feet, of considerable lifting capacity, but very sensitive to weather, more especially to rain or snow, which, lodging on the outer surface of the envelope, is liable to weigh them down. Their great length makes them difficult to handle in a cross-wind. They are fitted with a wireless telegraph installation which will enable them to communicate with ship or shore at a distance of 150 miles. They were originally intended to be fitted with a platform on the upper surface communicating with the central gallery and cars by a well-ladder, the object of this platform being a double one, first to enable observations to be made under more favorable conditions than from the cars, which are, of course, overshadowed by the vast bulk of the dirigible itself, and secondly, to carry machine or other automatic guns for protection against aeroplane attack from above, to which they are most vulnerable. This secondary purpose appears risky in view of the practically inevitable leakage of hydrogen from the gas-containers which, rising to the upper surface and becoming in contact with the air a most inflammable mixture, might easily be ignited by the flash of discharge from the automatic gun or any other fire-arm on the platform. In fact, this has been proved to be the case, and the idea of carrying guns on the latter has apparently had to be abandoned. These vessels can carry explosives in the shape of steel bombs (filled presumably with trinitrotoluol) to a total of two tons in weight. The largest used so far weighs 250 pounds, but the Germans are said to have designed projectiles of 500 pounds in weight for special air-raid purposes, and the crews are, of course, supplied with incendiary and illuminating projectiles in addition to searchlights to enable them to light up any spot on which they may intend to drop projectiles by night. The motive power is usually supplied by Maybach engines, aggregating 500 to 900 horse-power, and they have a possible safe radius of action of 500 miles in a straight line from their protective *hangar*, but their extreme sensitiveness to unfavorable weather conditions appears to have placed very strict limits on oversea voyages. For instance, two are said to have been brought down and sunk during the return voyage from the east coast, according to accounts received from North Sea fishermen. There are sheds capable of sheltering Zeppelin airships at Helgoland (2), Wilhelmshaven, Cuxhaven, Hamburg, and Kiel on the German coast, and at Aix-la-Chapelle (Aachen), Düsseldorf, Cologne (2), Bickendorf, and Treves, near the Rhine and within striking distance of Great Britain. In addition, the Germans are believed to have erected temporary sheds at various points in Belgium, among them Brussels, Antwerp, and Liége.

The Helgoland *hangar*, which is one of the best planned, is double, placed on a pivot so that it can be rotated to face the wind, and so arranged that it can be lowered by hydraulic apparatus into a deep pit in the ground. It is thus safe from attack by warships, unless a shell happens to pitch on it, and presents no mark to aircraft or guns.

The airships which took part in the raid on Yarmouth were apparently three in number, and they subsequently visited other places, including King's Lynn and the neighborhood of Sandringham, Cromer, and Sheringham.

Hostile aircraft were seen at 1:30 P. M. in the afternoon off the Dutch coast. They passed over the island of Terschelling and, crossing the North Sea, reached the English coast after darkness had fallen. Their presence was unsuspected until about 8:30 P. M., when bombs were dropped on Yarmouth. Considerable damage was done, and at least three lives were lost. The bombardment of the town from the air continued for some ten minutes. Several of the missiles did not explode, and one fell through a house in Yarmouth, without injuring the family within. The authorities promptly extinguished the street lights and the people seem as far as possible to have kept under cover. This probably made the death roll lighter than it would otherwise have been. In the darkness, however, it was impossible to distinguish the nature of the craft, which were believed to have carried searchlights.

Commenting on this raid in the *Times* of January 21st, the naval correspondent of that paper said:

"Now that the long-threatened invasion of these islands by Zeppelins has become an accomplished fact, and especially considering the comparatively small amount of damage that has been its result, it is natural to ask ourselves what its object was. Ever since the beginning of the New Year the enemy's aircraft have shown increased activity in several directions, but there has not been conclusive evidence that the Zeppelins have to any large extent taken part in these operations. As a result of the poor part they played in our combined sea and air-raid on Christmas Day there has been a manifest inclination to disparage their ability and to regard their powers as having been much over-rated. This being the case, it would not be surprising if the German authorities were anxious to show that they were capable of doing much more than might have been expected from their performance on that occasion. In other words, the raid was intended to restore their prestige, particularly in Germany, and once more to instill a feeling of apprehension in regard to their menace in this country. This is the most obvious reason for the raid.

"It would be a mistake, however, to accept this as the primary reason for the raid on Tuesday night. The duties of aircraft are scouting and the destruction, by means of bombs, of objects of military usefulness and importance. To these the Germans have added a third, which they term 'frightfulness'—raids which by the murder of non-combatants and the destruction of private property may strike terror into the inhabitants of a country in the hope that, by setting up a state of nervousness, an influence may be exerted on the progress and direction of the war. In our case, of course, the hope evidently is that the flow of reinforcements to the Continent may be stopped, whereas in point of fact the excursion of Tuesday is more likely to have exactly the opposite effect. In almost every case, however, the air-raids of the Germans have served a double purpose. They have combined reconnaissance with bomb-dropping. This last exploit was almost certainly in the nature of a test of the state of our defenses against aerial attack on the east coast if the objective in some future raid is to be a point further inland. The Germans may have obtained some satisfaction, therefore, at finding that the Zeppelins were not brought to action on this occasion.

"In view of the known capabilities of the Zeppelin type of airship, this can only be regarded as a trial trip. Whether there were two or more vessels engaged, they were seen off the Dutch islands a little after noon on Tuesday, and probably left their base half an hour earlier. They arrived over the East Anglian coast at 8:30 P. M., and therefore covered a distance of about 300 miles in little more than eight hours. This would allow them a speed of 36 miles an hour, which is about what they would accomplish at half power. They apparently went back much faster than they came, possibly owing to conditions of wind and weather. As, however, these airships have a radius of action of about 1,200 miles in suitable circumstances, there is hardly any portion of the British Isles that they could not reach, provided they were willing to make part of the journey in daylight. The latest rigid airships are capable of thirty hours' continuous flight at full speed—about 50 miles an hour—or they can do a sixty hours' flight with their engines working half power. Thus, had the vessels used on Tuesday come over at their highest rate of speed, they could have reached almost any of the larger English towns and got back before dawn. As the primary object of the German chiefs is always to lessen the power of the navy, and thus bring about conditions favorable to the use of their own fleet, it might be supposed that vital points like important railway junctions, towns where warlike material is being manufactured, or the big shipyards and arsenals, would be aimed at rather than undefended places like Sheringham and King's Lynn.

"It is fair to assume, therefore, that the Germans had more than one motive in making this air-raid, and that when repeated it will not always be aimed at defenseless towns. There is nothing to prevent the employment of aircraft against points far inland except such precautions as we may take, including the provision of anti-aircraft guns and the darkening of our cities. This defense is partly in the hands of the navy, and so might be also that which is the best defense of all—counter-attack by aircraft. But the Admiralty is not responsible for the protection of the country from everything that flies aloft. It must be pointed out, moreover, that just as it would be suicidal for the Admiralty to alter their naval dispositions and to distribute our naval forces up and down the coast for the ostensible protection of every seaport, so the aircraft we possess must necessarily be concentrated for the protection of the places of national importance.

* From the United Service Magazine.

which are obviously always open to Zeppelin assault."

The radius of action credited under suitable circumstances to Zeppelin airships in the above comments is a much larger one than the estimate given in the earlier part of this article, namely, 500 miles. It will be interesting to see if the oversea voyages of any airship during the present war should exceed the latter limit.

In a leader on the subject the *Times* remarks that it is significant that in this trial trip no attempt was made to reach London or any spot which might be supposed to possess considerable means of defense against air attack; also that minor reasons for the raid include the pressing necessity for convincing the German people that the Zeppelins are not useless toys. They can hardly be said, after six months of war, to have justified the large expenditure which has been incurred on their behalf. This does not imply that the principle of rigid airships for oversea work is wrong; the amount of capital and energy expended on this particular brand of aeronautics by Germany may have been misdirected, and Great Britain has never taken the airship seriously as a problem to be dealt with summarily and urgently, so that, so far, the investigation has never been carried to a logical conclusion in this country. Germany, previous to the war, had sunk £300,000,000 on her navy, and she must have spent a considerable sum in experimenting on airships, but it would have been far more worth our while to have spent more than she did in order to decide once for ourselves whether anything could be made of such delicate and vulnerable engines of war or whether they could safely be neglected. If they should prove to be of any use at all for oversea reconnaissance, it is logical to assume that they would be of more service to us as the chief maritime power than to the Germans.

In some of the later accounts of the Yarmouth air-raid it was stated as a surmise that six Zeppelins took part in the enterprise. As this statement was not based apparently on the accounts of credible eye-witnesses, it probably owes its existence to information furnished by the enemy. Referring to this Mr. T. F. Farman, writing in the *Field* of January 30th, said, in the course of an article on "The Zeppelin Raid":

"If the announcement be true that the Zeppelin raid on Yarmouth and the coast of Norfolk had been carefully prepared, and that after waiting a whole month for propitious atmospherical conditions, six dirigibles—Zeppelins or other types—started from Cuxhaven or Helgoland, or some from each of these places, with the intention of spreading terror in the mind of the British nation, Count Zeppelin must be rather disappointed, in spite of the congratulations he received from the Kaiser and the enthusiasm with which the news of the exploit seems to have been received by the whole German nation. Every civilized man or woman who is not imbued with German 'Kultur' must sincerely regret that a few innocent women and children fell victims to the projectiles dropped from these Zeppelins, and that a certain number of houses were wrecked. However, if the six German dirigibles all reached the English coast, or, indeed, if only two of those airships succeeded in crossing the Channel, the result of their attack was pitiably small in comparison to the extraordinary effort made, the risks incurred, and especially the much vaunted power of destruction of the aerial dreadnoughts. All the evidence which has been forthcoming renders it almost impossible to believe that if six dirigibles started on the murderous expedition they all arrived over the English coast, and if they did not, it would be interesting to know what became of them. Also there is no evidence that even those Zeppelins which dropped the bombs on Yarmouth, Sandringham, etc., returned safely to their sheds, wherever they may be situated. However, as in spite of the telegram from Leyden stating that fishermen saw a dirigible founder in the North Sea, there is at the moment of writing no absolutely convincing evidence to prove the contrary, the whole of the fleet, even if some of the aerial vessels had to turn back before they reached their destination, may have returned without disaster to Germany or to territory occupied by the German army. The weather was most exceptionally favorable for the exploit. The speed of the wind did not exceed 4 or at most 5 mèters a second, that is to say, it was blowing between nine and eleven and a quarter miles an hour.

"From a sporting point of view the voyage of a fleet of six dirigibles across the North Sea from Cuxhaven to Norfolk and its return to Germany undoubtedly is remarkable, but it is far from demonstrating the military value of those vessels. On the contrary, it goes far to prove that if they can act by surprise their pilots are conscious that they must keep out of reach of hostile guns, and above all, avoid giving aeroplanes the chance of sighting them. It will be remarked that after reaching the English shore the dirigibles kept close to the coast, well knowing that if by chance they were pursued by an avion their best chance of escape would be to take to flight over the sea, where they would soon be lost in the mist and darkness, and over which the aeroplane could not follow them for any very long distance without being provided with a specially large tank full of gasoline. Moreover, though the sphere of action of a Zeppelin is very considerable it is not unlimited. Carrying a ton of explosives, it is a very generous estimate to admit that it may be capable of traveling 750 miles, and to effect such a voyage the atmospheric conditions must be most favorable. Cuxhaven is separated from Yarmouth by a distance of about 285 miles, but the Zeppelins which crossed the North Sea hugged the Dutch coast and only steered in a straight line to Norfolk from Ameland Island. It may, therefore, be calculated they traveled some 300 or 310 miles before reaching the English coast. With the return journey the distance covered was between 600 and 620 miles, which approaches the maximum these vessels could travel with any reasonable chance of success. Consequently, even if they had had nothing to fear from fire from the earth or from attacks by British avions, they could not have ventured to extend their voyage as far as London. It is true that dirigibles starting from Belgium would have a shorter distance to cover to reach the British capital, but it is sufficiently considerable to make them hesitate to undertake it except under very propitious conditions, to say nothing of the danger they would run from attack by aeroplanes and fire from the earth or from vessels of war at sea. That the German aeronautical authorities are loath to expose their dirigibles to the attack of avions has been demonstrated by the manner in which they carefully avoid sending them on missions during the execution of which they are likely to encounter any of them."

To return to our chronicle of aerial raids, an official statement by the Admiralty showed that:

"On Friday, January 22nd, twelve or thirteen German aeroplanes appeared over Dunkirk at 11:30 A. M. and dropped bombs.

"No particular damage was done, except that a shed in the docks was set on fire. One of the bombs fell just outside the United States Consulate, breaking all the windows and smashing the furniture.

"Belgian, French, and British naval and military airmen engaged the German aeroplanes, one of which was brought down by a British military machine just over the Belgian frontier. The German aeroplane, pilot, and passenger were captured.

"During the day visits were paid to Zeebrugge by Squadron Commander Richard B. Davies and Flight Lieutenant Richard Peirse. Twenty-seven bombs were dropped on two submarines and on the guns on the mole.

"It is believed that one submarine was damaged considerably, and that many casualties were caused among the guns' crews.

"In making a reconnoitring flight before this attack Squadron Commander Davies was on one occasion surrounded by seven German aeroplanes, but managed to elude them. He was slightly wounded in the thigh on his way to Zeebrugge, but continued his flight, accomplished his mission, and is now progressing satisfactorily."

Then:

"On the 23rd of January a Turkish transport conveying sixteen aeroplanes for the Turkish army in the Caucasus was sunk by a Russian war vessel, and on the 25th of January a German dirigible, while attempting to bombard Libau, was brought down on the Baltic by artillery fire, and was subsequently destroyed and its crew captured."

The vessel in this case was a Parseval. Some interesting details of the raid on Dunkirk were given by the British "Eye-Witness" in the following terms:

"One of our aeroplanes—a single-seater—was on patrol duty, when the observer saw several hostile machines approaching. He at once gave chase to the first hostile machine and opened fire on it. Meanwhile two other British machines started from the ground. It took them some little time to ascend the height of 6,000 feet at which the action in the air was proceeding, during which the British machine which had been on patrol had succeeded in driving off with its fire the two leading German machines. Ten others, however, had come up by the time that the three British machines were all in action. After the Germans had dropped several bombs over the harbor and town the whole turned and flew back toward their lines. Our aeroplanes pursued and brought down one German machine, by a bullet through one of its cylinders. The aeroplane was captured, together with its pilot and observer and eight unexploded bombs. The observer was armed with a double-barreled pistol for firing chain shot. In face of the heavy odds against them this feat on the part of our aviators was distinctly meritorious. The damage done by the raiders was slight."

The last attack by aircraft recorded up to the middle of February was a series of combined aeroplane and seaplane operations which were carried out by our Naval Wing, as announced by the Admiralty on the night of February 12th-13th—"during the last twenty-four hours," the object being to prevent the development of German submarine bases and establishments, and which covered the districts of Zeebrugge, Blankenberghe, and Ostend. According to the official report:

"Thirty-four naval aeroplanes and seaplanes took part.

"Great damage was reported to have been done to Ostend railway station, which, according to present information, has probably been burnt to the ground; the railway station at Blankenberghe was damaged and railway lines were torn up in many places. Bombs were dropped on gun positions at Middlekerke, also on the power station and German mine-sweeping vessels at Zeebrugge, but the damage done was unknown

"During the attack the machines encountered heavy banks of snow.

"No submarines were seen.

"Flight Commander Grahame White fell into the sea off Nieuport and was rescued by a French vessel.

"Although exposed to heavy gun-fire from cities, anti-aircraft guns, mitrailleuses, etc., all pilots returned safely. Two machines were damaged.

"The seaplanes and aeroplanes were under the command of Wing Commander Samson, assisted by Wing Commander Longmore and Squadron Commanders Porte, Courtney, and Rathbone."

This statement is distinctly interesting on account of the attempt at hasty demolition of buildings and objects in connection with the enemy's nerve centers, being on the largest scale up to date to be carried out by heavier-than-air machines. The ascending scale of numbers employed for specifically aggressive purposes in these raids is worthy of note, as well as the extraordinary comparative immunity of both men and craft to damage by the enemy's fire. It is to be hoped that we shall be able to obtain in time some idea of the damage done by our airmen on this occasion.

Equilibrium of the Body*

The position of the eyes in the fishes and birds indicates that their area of vision without moving the head must be considerably larger than ours, and their sense of equilibrium therefore different. The swimming act is performed by the pectoral fins and telson, while the dorsal and ventral fins regulate the balance of the body, which is to right or left, similar to that of the birds. That the balance is to right or left can be observed with especial ease in the sparrow, which comes in flocks, while on the ground, rushing or fighting for food, the wings are not always entirely extended; frequently one wing is almost resting on the chest for an instant while its mate is stretched to its full length.

In the human body the equilibrium is kept up somewhat differently, being more of a pendulum-like motion, to and fro, when walking on smooth, level ground, the sacrum describes a continuous horizontal wave line, and if a disturbance of balance occurs, the body usually falls forward, seldom to one side.

The otoliths in the fishes and a few other marine animals can be regarded as annunciators which tell that something is passing outside. Whether the osseous labyrinth in our own ear is of the same character, or not, or whether it is merely an apparatus to aid in preserving equilibrium, is not known with certainty. Neither do we know whether we really see objects in their right position, or only seem to do so through habit, for they must be reflected upside down on the posterior part of the crystal lens of our eye.

Judging from the way pigeons, especially, tip their heads to one side to see where food is thrown on the ground, some lack in their forward vision is indicated and it would therefore seem that seeing the tips of both wings in the same sidewise glance were of more importance than direct forward vision. This ability to see both sides at once is an advantage which aviators do not possess.

Above a flat country, and an altitude of 10,000 feet, or more, the horizon is beneath the aviator and therefore his feelings about the right position of his aeroplane are lessened. Then, too, not passing any object, and being continually met by a strong wind, the airship seems to be standing perfectly still, and this produces a sleepy monotonousness which tends to make the aviator not always on his guard.

*Magnus Westergren in *Science Conspectus*.

Large quantities of hydrochlorite of soda are used in the laundry of a large English hospital, where it is found to be effective in destroying micro-organisms and removing stains, without appreciably injuring the fabrics. This solution is prepared on the premises by the electrolysis of a 4 per cent solution of common salt in water. With an expenditure of 10 amperes direct current at 220 volts, twelve gallons of the hydrochlorite solution are produced per hour, which is diluted with nine times its volume of water for use.

Wireless Transmission of Energy—I*

An Explanation of its General Nature and Relationship to Transmission By Wire

By Elihu Thomson

It will be my purpose in the present discourse to outline the general nature of wireless transmission and to indicate its relationship to transmission by wire. It will also be my object to show why the wireless energy sent out follows the curvature of the earth and to explain other features which to many have been more or less puzzling. In short, I desire to present in simple terms a view of the nature of such wireless work, so that anyone reasonably informed about electrical actions can obtain, as it were, a mental picture of the process. I may here state the fact that perhaps one of the earliest experiments bearing on wireless transmission was made in company with Prof. E. J. Houston, while we were both teachers in the Central High School in Philadelphia. This old experiment to which I refer was made about the latter part of 1875, and briefly described in the Franklin Institute *Journal* early in 1876. It consisted in using an induction coil which would give a spark length of several inches, then known as a Ruhmkorff coil, the coil resting on the lecture table, one terminal of the fine wire or secondary of which was connected to a water-pipe ground, while the

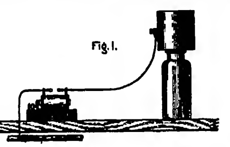


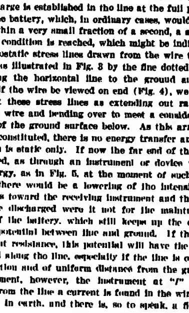
Fig. 1.


Fig. 2.

other was connected by a wire 4 or 5 feet long to a large tin vessel supported on a tall glass jar, insulating the tin vessel from the lecture table. The coil had an automatic interrupter for the primary circuit, and when in operation the terminals of the secondary were approached so that a torrent of white sparks bridged the interval between them, the gap being about 2 inches or so in length. Fig. 1 shows this arrangement. When the coil was worked in this way, it was found that a finely sharpened lead pencil approached to incipient contact with any metallic object, such as door knobs within the room and outside thereof, would cause a tiny spark to appear at the incipient contact between the pencil point and the metal. This, of course, was not a very delicate detector, but was improved, as in Fig. 2, by putting two sharpened points in a dark box, a device due to Edison. One or both points were adjusted so as to make incipient contact, and the tiny spark observed between the points was an indication of a shock, commotion or wave, electrical in its character, in the ether surrounding the tin vessel mounted on the glass jar. The tests for detecting the impulses were carried on not only in rooms on the same floor, but on the floor above and on the floor above that, and finally at the top of the building, some 80 feet away, in the astronomical observatory. Metallic pieces, even unconnected to the ground, would yield tiny sparks, not only in the basement of the building, but in the highest part, with several floors and walls intervening. I mention this old experiment particularly because it has in it the elements, of course in a very crude form, of wireless transmission, the wire and tin vessel attached to one terminal of the coil being a crude antenna with its spark-gap connection to ground, as afterwards used in wireless work by Marconi, and it also shows a rudimentary receiver or detector, a metallic body arranged in connection with a tiny spark gap, so that electrical oscillations in such body would declare themselves by a faint spark at the gap. It was understood by us at the time that after each discharge of the coil there was, as it were, a shock, or wave in the ether consisting of a quick reversed electrical condition, and it was even imagined that there might be in this process the germ of a system of signaling through space. This old work was almost forgotten when it was recalled by the later work of Hertz, about 1887, who demonstrated by suitable electrical apparatus that waves of the general nature of light or heat could be generated, which waves are transmitted with the velocity of light, 186,000 miles per second, and that by suitable resonators or detectors these waves could be made to declare themselves by tiny sparks. The Hertzian oscillator was, as it were, an electrical tuning fork, having an actual rate of vibration peculiar to itself and dependent on its form and dimensions. It was fed with energy from an induction coil and across its spark gap an oscillating discharge took place, which, at each impulse, died out like the discharge of a condenser, but during this discharge it electrically stressed the ether in one and the other senses, so that an electrical wave was radiated in certain directions from the oscillator. It was found that these waves could be refracted, reflected and polarized, and, in general, dealt with as extremely coarse light or heat waves. We shall refer to these, however, farther on. The general result, however, of the Hertzian experiments was to connect electrical waves in the ether surrounding the apparatus with the light and heat waves and prove the identity of the two kinds of radiation, the differences being only those of wave length or pitch.

Since the Hertzian waves were sent out from the Hertzian oscillator in substantially straight lines, and since in the early days of wireless telegraphy it was common to regard wireless waves as of the same nature or as almost identical with Hertzian waves, the fact that the wireless waves were found to follow the curvature of the earth became a difficulty to be explained. Speaking for myself, I have never found the difficulty to exist. There is really no reason why the waves should not follow the curvature of the earth, as it will be one of my purposes to show. We will, however, approach the conditions of wireless somewhat gradually.

We will first consider an ordinary wire transmission of the simplest type. Let us assume a line of wire, as in Fig. 3, insulated and connected to one terminal of the battery while the other terminal is earthed or grounded. A simple telegraph system on open circuit would represent this arrangement. The only effect is that the battery supplies a small charge to the line, producing a potential difference between the insulated line and the earth, assuming, of course, that there is no leakage of any kind to disturb the conditions. As soon as the charge is established in the line at the full potential of the battery, which, in ordinary cases, would take place within a very small fraction of a second, a steady or static condition is reached, which might be indicated by electrostatic stress lines drawn from the wire to the ground, as illustrated in Fig. 3 by the fine dotted lines connecting the horizontal line to the ground surface below. If the wire be viewed on end (Fig. 4), we must represent these stress lines as extending out radially from the wire and bending over to meet a considerable portion of the ground surface below. As this arrangement is constituted, there is no energy transfer and the condition is static only. If now the far end of the line is earthed, as through an instrument or device which uses energy, as in Fig. 5, at the moment of such connection there would be a lowering of the intensity of the stress toward the receiving instrument and the line would be discharged were it not for the maintaining action of the battery, which still keeps up the difference of potential between line and ground. If the line is without resistance, this potential will have the same value all along the line, especially if the line is of uniform section and of uniform distance from the ground. The moment, however, the instrument at "I" takes energy from the line a current is found in the wire and a return in earth, and there is, so to speak, a flow of


Figs. 7, 8 and 9.

energy in the space between the wire and the earth and in the ether surrounding the wire, in the direction of the arrow; that is, from the generating end to the receiving end. Surrounding the wire at this time there will be a magnetic field, which may be represented by whorls or lines of magnetism, so called, wrapped around the wire like so many hoops of all sizes (Fig. 6), expanding in size away from the wire in all directions; and a similar magnetic effect, of course, is also produced by the return current in the earth. But, on account of the conditions of conduction in earth being very devious and irregular, it would be difficult to map the magnetism generated. The system of magnetic whorls so developed on the flow of the current in the system reaches, for any definite current, a definite density after a short interval. In other words, the density of the magnetic field between the wire and the earth increases only up to a certain point. If the current, however, be doubled in any way, that field is doubled in density or there are twice as many lines packed in the space around the wire. If now we took instead of an earth-connected circuit one in which there are two wires extending from the generating battery or generator, the

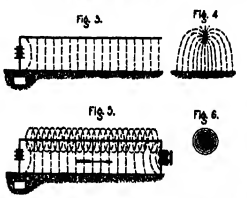


Fig. 3. Fig. 4

Fig. 5. Fig. 6.

conditions will be the same except that the stress lines will now radiate from each wire and connect the wires by lines directly between them and by other curved lines outside. Such lines, or otherwise conceived "tubes of force," represent the static field or the density and directions of electrostatic stresses in the electrostatic field where one wire will be positive while the other is negative. If, as before, the ends of the wires are free or open-circuited, no energy is transmitted, and the mere static stress exists. If, however, the wires are connected through an instrument receiving energy or utilizing the energy, then the magnetic system is developed, surrounding each wire and passing between the wires, and on the establishment of any given current these lines accumulate at a rapid rate until, in a small fraction of a second usually, a limit is reached. The magnetic field may then be said to be fully developed. Outside of the pair of wires the magnetic disturbance extends to very great distances, but is necessarily weak far away. The magnetic whorls in this case do not center themselves in circular paths around the wires and at equal distances therefrom, but between the wires they are more condensed or pushed toward the wires themselves—crowded, so to speak—while outside of the wires they expand (Figs. 8 and 9). It must be remembered that these lines of force are merely symbols for what may be likened to a magnetic atmosphere. They indicate the density and direction of certain actions in the ether, called magnetic. It will be important to note, both in wire and wireless transmission, that the energy is transferred in the surrounding medium. The wire in ordinary wire transmission is, in fact, a sort of guiding center or core around which this ether disturbance carrying the energy exists. The wire may be bent or coiled, expanded or contracted without altering the essential nature of the process. So far, then, ordinary wire transmission is really a case of wireless transmission, with the wire for a guiding core for the energy (Fig. 10).

It would take us too far to attempt to explain or theorise on the modern view of the passage of electrons in the wire forming the current, and the field they carry with and about them in giving rise to the stresses in the ether surrounding them. Suffice it to say that a moving electron must not only be accompanied or surrounded by the static stress field which it produces in the ether, but also by a magnetic effect representing the energy of motion possessed by it. When a current which has been started in a circuit reaches a definite

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value it may be said to have reached a steady state. It would then be a continuous current of constant value. Energy can be steadily extracted from such a system only by introducing some apparatus connected with the wire which is the guiding core for this energy.

Let us now consider the case of current of a different character, a fluctuating, or better, an alternating current. Let us substitute for the battery an alternating current generator, and assume a single wire with an earth or wire return, as in Figs. 3 and 5. Here the wire merely becomes positive and negative alternately, for the circuit is incomplete or unconnected as a circuit, and the stress lines from wire to earth or to other wires reverse periodically their direction plus to minus and

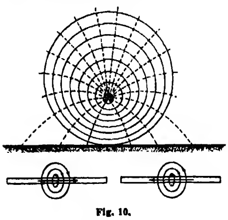


Fig. 10.

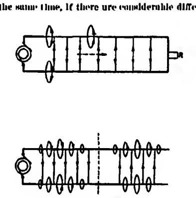
minus to plus. This is true, of course, whether the earth be replaced by a second wire or whether three or more wires be involved, as in a three-phase alternating current circuit. By connecting any two of the wires through an energy-receiving apparatus *R* (Fig. 11), the same action that takes place with the continuous current may be reproduced except that the energy now comes in waves and is not a continuous flow. In ordinary cases there are sixty complete waves or complete changes from plus to minus and back to plus in each second, and the system is then called one of 60-cycle frequency. A further important difference is to be noted between the alternating-current condition and the continuous. The action in the ether around and between the wires is now in the form of waves, both magnetic and electrostatic. Between wires there is an increase of electrostatic stress to a maximum, a diminution to zero, a reversal, etc. The magnetic field also rises, falls, reverses, and so on synchronously. The condition is no longer static, the medium around the wires is in a dynamic state, and it is now possible to abstract energy steadily from it without actually diverting current from the line. We can, in fact, by such a system produce in neighboring conductors similar disturbances or currents, and along with these disturbances we may deliver energy.

The alternating-current transformer is then merely a device for bringing two or more circuits together as near as possible and enhancing the magnetic values which would normally exist around such circuits by the addition of an iron atmosphere, the iron core, so that the greatest possible transfer of energy from one (the primary circuit) to the other (the secondary circuit) may be accomplished. But in the wire itself, which leads from an alternating-current source, since there is an action called a current which changes, pulsates, or alternates, we have also around the wire core waves in the ether which, in fact, spread to very great distances; some small portion of the energy of each impulse not returning to the system, but passing outward into space as radiated energy.

This radiation may be a very small amount per cycle, especially where the outgoing and return wires are near together and parallel, and with low frequencies, such as 60 cycles, on account of the low number of waves per second and the low speed or rate of change in the fields surrounding the wire, the amount of energy carried off by free radiation into space is indeed negligible. But if we raise the frequency we raise the amount of energy which can be radiated proportionately to the number of waves per second, and we also make the rate of change higher and the wave slopes steeper, so that as the frequency rises the radiation factor becomes more and more important in dissipating the energy of the system. It is diffused through space around the electric system at work and passes off to illimitable distances. Since these impulses in the wire, the electrical waves sent along the wire (with the wire as a guiding core), can at the maximum move with the speed of light —186,000 miles per second—it follows that if the line is sufficiently long or the transmission sufficiently extended or the path of radiation sufficiently distant the wave stresses or fields or currents can exist at different parts of the system in phases either much displaced or entirely opposite. This may be rendered clear by stating that while one portion of a very long line might be positive to earth another portion half a wave-length distant from the first along the same line would be negative to earth (Fig. 12). In other words, there may exist upon the system at the same instant a succession of waves in opposite phase. Just as in vibrating strings in musical instruments or vibrating columns of air in organ pipes there are stationary waves, nodes, and internodes, so in electrical systems in vibration there can be nodes and internodes if the conditions are selected for obtaining that effect. Here the dotted vertical line indicates the nodes of the waves. We may thus have so-called stationary electric waves (Fig. 12).

We find that on raising the frequency of an alternating-current system from, say, 60 cycles, the ordinary frequency, to 600 cycles, an effect which at first was hardly detectable now becomes important. It is the so-called "skin effect" whereby the current in a wire circuit tends to concentrate itself on the outer skin of the conducting wire, neglecting the inner copper, so that the inner core of the wire might be left out. Consider the frequency still further raised, say, to 6,000 cycles, this "skin effect" of the conductor still further increases until the copper in the interior of a circular wire of a considerable size is now quite useless, and to get the advantage of such copper we must, as it were, take it out or spread it in a number of parallel wires spaced apart, or make the metal of the conductor in the form of a long sheet or in the shape of a thin tube or a cage of wires (Fig. 13). This, in electrical terms, improves the conductivity and reduces the opposition due to self-induction; the inductance counter electro-motive force. Let now the frequency be still further increased to tens of thousands or hundreds of thousands of cycles per second; then our conductor must necessarily become a still thinner or a still more extended sheet.

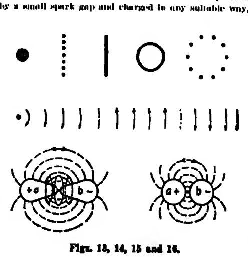
At the same time, if there are considerable differences



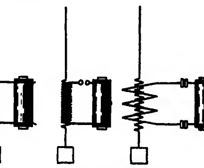
Figs. 11 and 12.

of potential between the conductors thus arranged, the radiation factor may at last become very important, so that if the parts of the circuit are far apart, free radiation into space may dispose of a large fraction of the energy sent out. In the Hertzian oscillator, deducting that lost in the spark gap, practically the whole of the remaining energy supplied is radiated into space. The wave frequency may be very many millions per second, and the waves produced are in the nature of coarse light and heat waves. Fig. 14 exemplifies diagrammatically the fact that with very high frequency waves a conductor carrying such waves will have surrounding it, if the space is unrestricted, magnetic systems of lines reversed in direction with nodes between, the distance apart of these waves or nodes being determined by the frequency in relation to the velocity of light, each complete wave outside the wire occupying a length equal to the velocity of light, 186,000 miles per second, divided by the wave length or frequency.

Figs. 15 and 16 represent forms of Hertzian oscillator, consisting of plates or spheres *ab* of metal, separated by a small spark gap and charged in any suitable way, plus and minus with respect to each other, and allowed to discharge across the gap. The charges are then interchanged between *a* and *b* at a very high rate, though the waves decay rapidly, and the system vibrates only for a short time or until the energy of the charge is dissipated in ether waves of exceeding high pitch into the surrounding medium. Were there no energy lost in the gap itself for forming the spark, and if the metal were a perfect conductor, the full amount of energy represented by any initial charge would be dissipated in the ether in these ether waves. Marconi, however, in his development of wireless telegraphy did not use the complete Hertzian oscillator. In setting up his



Figs. 13, 14, 15 and 16.



Figs. 18, 19 and 20.

transmitting antenna he took substantially half an oscillator, the other half being, so to speak, a phantom—the reflected image of the first half, as it were, in the surface of the earth, generally the sea surface. It would be represented by taking an extended copper sheet or surface coated with a fairly good conductor to represent the earth's surface and mounting above it, but insulated from it, a metal body, such as a vertical rod, which could be charged and which could discharge to the sheet through a small air gap. In this arrangement not only would waves be sent out into the surrounding ether space, but there would be current traversing the sheet as waves of current around the spot where the discharge of the insulated body took place. In fact, I think it would be possible to represent experimentally a modern wireless system with a diminutive antenna to represent the transmitting station, and extended copper sheet to represent the earth's surface, and with investigating or receiving antennæ set up here and there or moved from point to point on the extended surface.

Here, although the disturbance and the energy conveyance is in the ether around the antenna (or the part representing the half of the Hertzian oscillator), the energy is guided in its direction by the current in the sheet representing the surface of the sea, just as in the wire transmission the energy is guided by the wire as a core. On account of the enormous extent of the earth's sea surface, there is no need of a return circuit. The energy sent out moves in all directions, guided by the conducting water surface or land surface, as the case may be. There will necessarily be a rapid attenuation of the energy as it leaves the sending or transmitting antenna and spreads out to fill a wider and wider space around it. The higher the sending antenna the greater the distance which can be reached before the attenuation is too great for imparting signals.

Let us consider for a moment by the aid of a figure the actions which must occur in wireless transmission on the sending out of energy from the transmitting antenna. Referring to Fig. 17, we will represent by *e—e* the surface of the earth as if it were flat, and for moderate distances this will be substantially the case. We will erect on that surface a tall mast *A* of conducting wire or wires which, at the top, shall have an extension to increase its capacity. This might be a large ball of sheet metal. Usually, for construction to be practicable, it is a set of wires—a sort of cage or a skeleton body. Now, by any system, inductively, conductively, or otherwise, or by what is known as close or loose inductive coupling or what not (Figs. 18, 19, 20) we cause electric disturbances, such that at one instant the top of the antenna becomes positive and at the next instant

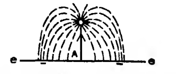


Fig. 17.

negative, many thousands, even hundreds of thousands, of times per second. In other words, we impress a high-frequency wave upon this vertical mast. We will try to present an instantaneous picture or form an instantaneous image of what the condition is at the beginning of the process.

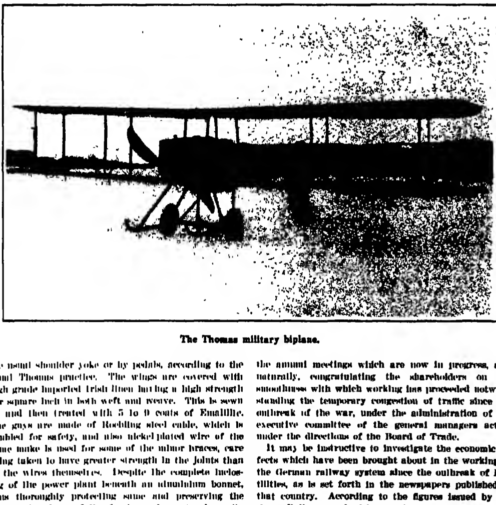
(*To be continued.*)

The Thomas Military Tractor Biplane

The annexed photograph gives a good idea of the general appearance of the latest military tractor biplane to be constructed for the Government competition, which was held last fall at San Diego. The Thomas military machine has all the up-to-date features required by the Government and even with the 90 horse-power Austro-Daimler motor used, it has shown remarkable speed variation and great climbing ability. With a motor of 150 horse-power, which is what is being used chiefly abroad on military machines nowadays, this machine would be equal to any of those taking part in the present war in Europe.

The wing curve used in the planes of this new machine is that designed and tested by M. Eiffel and found to have the extremely high lift to drift ratio of 1 to 20. Besides this it is particularly adapted to fast climbing with a load, the machine having ascended 4,000 feet in ten minutes (800 feet in the first minute) with pilot, two passengers, and a four hours' supply of fuel. It has also developed a speed of 82 miles per hour when fully loaded and has flown as low as 38 miles per hour. Besides fuel and oil for four hours the machine is figured to carry an additional load of 450 pounds.

The dimensions of this new tractor are 30 feet spread with a 5-foot chord and a 5-foot gap. Its overall length is 26 feet. It is provided with a simple running gear of the two-wheel two-skid type, 26 by 4-inch tires of great resiliency being fitted, the usual rubber band shock absorbers being used as well. Ailerons are fitted to both ends of each plane and are operated either by



The Thomas military biplane.

the usual shoulder yoke or by pedals, according to the usual Thomas practice. The wings are covered with high grade imported Irish linen having a high strength per square inch in both weft and weave. This is sewn on and then treated with 5 to 9 coats of Emaillite. The guys are made of Roebling steel cable, which is doubled for safety, and also nickel plated wire of the same make is used for some of the minor braces, care being taken to have greater strength in the joints than in the wires themselves. Despite the complete inclosing of the power plant beneath an aluminium bonnet, thus thoroughly protecting same and preserving the stream line form of the fuselage, the motor is easily accessible and can be quickly reached in all its parts, if anything needs attention. Throughout the whole machine accessibility and quick assembling and dissembling of the parts have been the points kept in view in making the design. The struts and wings can be very readily put together or dissembled as the case may be. The factor of safety is seven in every part of the machine. This is, we believe, somewhat higher than is used on many aeroplanes. The machine is a two seater having aluminium bucket type seats suitably upholstered and arranged in tandem. On the dashboard in front of the pilot's seat are fitted the usual gasoline pressure gage, revolution counter, inclinometer, barograph, and Pitot tube air speedometer, as well as the switch and gasoline shutoff. The spark of the magneto may also be advanced. The consumption of gasoline with the Austro-Daimler motor is but 9 gallons per hour, while less than one half gallon of oil is used. The mahogany propeller has shown an efficiency of 79 per cent in Eiffel's laboratory test. It, too, has a factor of safety of seven. White ash is used in the construction of the fuselage, all the longitudinal members being of I section and tapered to reduce weight. The struts and cross members are attached by means of steel clips so that no holes are drilled in the longitudinal members. These clips and all the turn buckles, I-bolts, etc., are of steel having a high tensile strength. Following is a table of the requirements made by the army and the actual performance of the new Thomas tractor. The weight of this new machine empty is approximately 1,075 pounds.

U. S. ARMY REQUIREMENTS.

Speed	70 miles per hour
Useful load	750 pounds
Climb, fully loaded	4,000 feet in 10 minutes
Slow speed	40 miles per hour
Propeller efficiency	70 per cent

Inherent stability.

RESULTS OF THE THOMAS BIPLANE.

Speed	81.1 miles per hour
Useful load	800 pounds
Climb, fully loaded	4,000 feet in 10 minutes exactly
Slow speed	38 miles per hour, approximately
Propeller efficiency	75 per cent

Very stable indeed.

German Railways and the War

The part played by the railways in connection with the present war has been, and is, of an exceedingly prominent character, both in Great Britain and on the Continent of Europe, and the chairmen of the English companies, as is shown by the speeches delivered at the annual meetings which are now in progress, are, naturally, congratulating the shareholders on the smoothness with which working has proceeded notwithstanding the temporary congestion of traffic since the outbreak of the war, under the administration of the executive committee of the general managers acting under the directions of the Board of Trade.

It may be instructive to investigate the economic effects which have been brought about in the working of the German railway system since the outbreak of hostilities, as is set forth in the newspapers published in that country. According to the figures issued by the State Railway authorities at the end of January, an enormous decline took place in the receipts from the goods traffic on the Prussian railways in the month of August, including receipts charged for military transport purposes, although a progressive improvement ensued in each succeeding month to the end of the year. The receipts in August, for instance, are returned at 41.25 per cent of the receipts from goods traffic in the equivalent month in 1913; in September, 68.73 per cent; October, 79.67 per cent; and November, 81.41 per cent; while for December, as was announced by the Prussian Minister of Finance in the Prussian Diet on February 10th, the receipts amounted to 95 per cent of those realized in the same month of 1913. If the figures can be relied upon as being accurate, the decline which took place in the opening months of the war must be considered to be small; the reduction, indeed, is said to be even less than what occurs in an ordinary period of receding commercial prosperity. As the production in many branches of trade, as, for instance, coal mining, iron and steel manufacture, etc., has been, and still is, largely restricted in consequence of the comparative scarcity of labor, it is assumed that important displacements in traffic have occurred by the railway transport of commodities which were formerly conveyed by waterway or sea route from the east to the west of the country. In the case of the passenger service on the Prussian railways, including troop trains, the financial results have been proportionately more unfavorable than those derived from the goods service. As compared with the equivalent months in 1913, the receipts from the passenger traffic are recorded at 56.51 per cent in August, 49.59 per cent in September, 61.89 per cent in October, 75.36 per cent in November, and 68.1 per cent in December. It is calculated that the reduction in the receipts from the goods traffic in 1914 has amounted to £13,000,000 ($65,000,000), and that from the passenger traffic to £6,500,000 ($32,500,000), making a total decline of £19,500,000 ($97,500,000) as compared with the preceding year, when the combined receipts were £163,000,000 ($815,000,000). The Prussian Minister of Finance, in the course of a speech delivered before the Lower House on February 9th, stated that while the railways solely served the purpose of goods and passenger traffic in times of peace, they were a mighty and important instrument in the conduct of war. In announcing that the receipts from the goods traffic in December had risen to 95 per cent of the total in the same month in 1913, as previously mentioned, the Minister remarked that the development was an eloquent indication of the great extent to which the economic life of the country was again pulsating and again flourishing. The proportion of working expenses to receipts had increased, but any deficiency was expected to be met out of the equalization fund, which was declared to exceed £16,000,000 ($80,000,000).

If the German figures concerning the percentages of receipts are trustworthy and have not been prepared for public consumption, they certainly show remarkable results under the conditions which prevail in that country. The coal industry, for instance, is only working at 60 per cent of the normal output and a comparative scarcity of coal exists, while the production of the iron and steel trades is only about an average of 50 per cent of the normal rate. But as the export trade in coal and iron and steel is insignificant at the present time, nearly the whole of the output is being absorbed by the home market. With the limitation in other industries it seems incredible that the goods traffic could have reached in December within 5 per cent of the receipts which were earned in the corresponding month in 1913, and the German statement may therefore be accepted with considerable reserve. At the same time, there is less reason for doubting the assertions that the German State Railway authorities have in operation seven Russian, nineteen Belgian, and three French railways, in the working of which 42,000 Germans are employed, and that the sole object of the invasion of Russian Poland in September and November was the destruction of railways and roads which might be of service for the Russian army.—*The Engineer.*

The Schumann Region of the Spectrum

Between the shortest Schumann waves and the waves of the X-rays there is at present a gap in which the relation between light and matter undergoes a profound change, and while further exploration of the region would undoubtedly reveal results of the greatest value, the difficulties in the way are enormous. Still with the knowledge of other difficulties, apparently fully as great, that have been successfully overcome by scientific investigators, it would not be safe to say that anything is impossible. Indeed, a considerable step has already been made in the desired direction by Dr. T. Lyman, who has succeeded in photographing the spectrum to wave-length 905, which is really a greater advance than Schumann accomplished, in view of the continually increasing difficulties, and an account of this work is given in "The Spectroscope of the Extreme Ultra-Violet," published by Longmans, Green & Co., London.

A most interesting portion of this work is the description of the apparatus employed. The opacity of air, glass, and quartz to the Schumann rays renders it necessary that the entire spectrograph and source of light should be inclosed in a vacuum, and that special materials should be used for the construction of lenses and prisms; specially prepared photographic plates are also necessary. Schumann made use of a vacuum spectrograph having prisms and lenses of fluorite, but Prof. Lyman has employed a concave grating of one meter radius, which is much simpler in adjustment and has the great advantage of permitting the determination of wave-lengths.

Prof. Lyman also discusses the absorption of many gases and materials in the region of short wave-lengths, as well as the spectra of various elements. The work will be found indispensable to those who propose investigations in the ultra Schumann region.

The Uses of Light in the Treatment of Disease*

Its Value as an Efficient Remedy When Properly Employed

By E. C. Titus

From time immemorial the beneficial influence of sunlight upon animal and vegetable life has been recognized, but it is only at the present time that we are appreciating its full value in the treatment of disease.

The excellent and even wonderful results of heliotherapy in the treatment of bone tuberculosis, to which attention has been called within a recent period, will serve as an illustration.

For obvious reasons, however, sunlight is not always available, and it has therefore been found advantageous to resort to other sources of light. Thanks to the progress made in electricity, we now have at our disposal various means of obtaining light closely approaching that of the sun in its remedial action, and to these means, chiefly, my paper will be devoted.

It must be remembered that the thermic effects of light are due to the impingement of the rays upon the translucent cutaneous tissues. The arrest of the light rays by the skin and subcutaneous structures produces radiant heat which has a higher penetrating power than convection heat as generated by a hotwater bag or poultice, for instance. It has been found that the thermic effects of light extend to a depth of two inches or more, while convection heat is principally exerted upon the surface. In comparing the therapeutic action of both it will be seen that the changes produced in the tissues by the former are much more pronounced. Thus if the body be exposed to an intense light, as in an electric light cabinet bath, the resulting hyperemia and elimination of waste products by the skin and kidneys (cellular nutrition) are much more pronounced than in a Turkish or Russian bath. The marked augmentation of the oxidation processes in the tissues is shown by the greater amount of carbon dioxide thrown off by the lungs and by the increase of solids in the urine. It is also claimed that the natural defences of the body (phagocytosis) are greatly promoted.

The actinic or chemical rays play an important part in phototherapy only when the light is concentrated upon a localized area as in the use of the arc lamp. Under these circumstances the actinic rays appear to enhance as well as modify the action of the thermic and luminous rays. Thus the ultra-violet radiations, which are actinic, have been shown to exert an anti-bacterial action as well as to promote local phagocytosis.

The general application of phototherapy consists practically in the use of the electric light bath, and since much of the benefit to be derived from this agent will depend upon the apparatus employed, I will first give a description of what has proven to me to be the most satisfactory type of cabinet.

An electric light cabinet should be constructed according to the following plan: The cabinet should be octagonal in shape, 4 feet square by 5 feet high; the lining should be of white blotter and not mirror surface; the source of light should come from 100 40-watt tungsten lamps, conveniently arranged, so that they will be under control from within by properly placed switches, one half or full number of the lamps to be employed, as desired. The cabinet should open at the top, not entirely, but partly so and it should have an air vent 3 inches in diameter in the center of the floor, over which is placed a low stool 18 inches high, upon which the subject is seated. (It has been found that a ventilated room is much more quickly and evenly heated artificially than one that is closed or sealed.) The further advantages of this construction are that a large volume of light with a minimum amount of heat is produced in the cabinet, that the emanations of noxious gases and odors from the human body are quickly carried off, that the degree of cutaneous hyperemia and diaphoresis is much more intense, and that the usual depression and other unpleasant symptoms are entirely obviated, as compared with the older form of closed cabinet.

Among the conditions in which the electric light bath has proved to be most serviceable are arteriosclerosis (hardening of the arteries), gouty and rheumatic conditions, Bright's disease, diabetes, obesity and acute catarrhal affections of the respiratory tract.

In the majority of cases of arteriosclerosis in the earlier stages I have advised the regular use of these baths with beneficial results, and I firmly believe that they have warded off more serious organic changes which otherwise frequently ensue.

The effects of these baths are:

1. To induce intense hyperemia or reddening of the skin and thus reduce the congestion of the deeper organs, which is frequently present.

2. To increase elimination by way of the lungs and skin. It has been found that during and following the bath the elimination of carbon dioxid is practically doubled, while the profuse perspiration produced carries away much toxic or poisonous material and in that way relieves the overtaxed kidneys. As it is generally accepted that toxemia plays an important part in the causation of hardening of the arteries, the benefit to be derived from this method is readily apparent.

Rheumatic and Gouty Affections.—In late years it has been frequently pointed out that many conditions commonly termed rheumatic differ essentially from the acute type of the disease which is very probably of bacterial origin. On the other hand, there is abundant reason to believe that those chronic forms which have been grouped under the names of rheumatoid arthritis, rheumatic gout, osteo-arthritis, arthritis deformans, are the result of auto-intoxication and disturbances of metabolism. From what has been said above it will be readily understood that the marked effect of the electric light bath in increasing elimination will exert a beneficial influence upon the toxemia in these cases and therefore prove of material aid to other treatment. The distressing pains and stiffness in the joints are also greatly relieved as patients have frequently assured me. In chronic gout, which is more frequent in this country than is generally thought, the action of light baths is to augment the cutaneous or peripheral circulation and in that way favor the absorption of uratic or chalky deposits.

It may be asked why a Turkish or Russian bath will not do equally well in the conditions mentioned. My own experience has shown that the effect of the light bath is much more pronounced and prolonged.

Bright's Disease.—One of the chief aims in the treatment of Bright's disease is to lessen the work of the kidneys. The light bath will be found a better auxiliary measure for accomplishing this purpose than the usual hot pack or steam bath. As previously pointed out, notwithstanding the profuse sweating induced, the patient experiences no depression because of the stimulating effect of the light energy upon the peripheral nerves.

Diabetes.—The light baths are not adapted to every case of this disease, but particularly to patients who present a dry skin with various cutaneous eruptions, especially of an eczematous character. The best results are obtained where diabetes is attended with high blood pressure.

Obesity.—The heat penetration in an electric light bath which, as already mentioned, extends to a depth of over two inches, stimulates the oxidation processes in the fatty tissues and promotes their disintegration in cases of obesity. It will thus prove an excellent auxiliary to the customary treatment.

Acute Catarrhal Affections of the Respiratory Tract. The writer has frequently had an opportunity to witness the beneficial effects of an electric light bath at the beginning of a cold in aborting it or greatly ameliorating its course. From personal experiences there can be no question of its superiority over the customary hot bath and diaphoretic (perspiration inducing) remedies.

In the local applications of light the following means are available:

1. The arc light, which is best employed by means of an ordinary marine searchlight, with its glass front window removed. The one I employ consumes 25 to 35 amperes of direct current at 40 volts, and projects the light in parallel rays by means of a 12-inch parabolic reflector, and has a light value of about 5,000 candle-power.

2. The high power incandescent lamp with a carbon or tungsten filament of 500 candle-power and provided with a dome reflector. The carbon filament uses 12 amperes at 110 volts, while the tungsten lamp consumes only 3 amperes at 110 volts. The former gives off more thermic rays, while the latter produces a greater amount of white light with a minimum amount of heat.

As already mentioned in discussing the general applications of light, it constitutes a means of generating heat within the tissues down to a depth of two inches or more, while convective heat is far less penetrating. Moreover, besides the conversion of light rays into heat, we have to deal with the chemical actinic rays which also play a not unimportant part in phototherapy.

The sum total of the combined effects is as follows. There is an increased local activity, as manifested by a pronounced hyperemia and an augmented tissue oxidation and elimination. The effects of radiant energy, however, are not confined to the site of application, but are so diffused that remote effects are produced in distant organs and nerve centers as a result of peripheral or cutaneous stimulation. It is easy to understand that the increased circulation, oxidation and elimination in the affected part will relieve congestion and promote absorption of exudates and deposits and the excretion of toxic materials. It has likewise been shown by physiological investigators that the heat production in the tissues increases phagocytosis and thus enhances the vital resistance.

The rapid relief of pain and local spasm experienced from light therapy is due in a great measure to the reduction of congestion and to tissue relaxation. In this connection it may be emphasized that these decided effects are brought about without the least risk to the patient, a statement which is not applicable unreservedly to other methods of treatment.

The employment of the parallel rays from a high power marine searchlight as described above, applied for 30 minutes to the spine at a distance of 10 feet, is one of the most effectual and lasting means of relieving many forms of spinal congestion.

In the acute stages of bronchitis or in pulmonary congestion from almost any cause, light applications to the chest afford a more prompt relief of chest pain and respiratory distress than any other measure with which I am familiar. In cases of chronic bronchitis marked benefit is obtained by prolonged daily applications of light to the front and back of the chest, continued until marked redness and tanning of the skin is produced.

To promote more speedy absorption in pleurisy I know of no better means than the daily use of phototherapy. In lobar and bronchial pneumonia its beneficial influence is manifested by marked relief of pain and dyspnea (shortness of breath) and an improvement in the general comfort of the patient; and in cases where resolution was delayed, it seemed to hasten this process.

I have frequently had occasion to resort to this treatment, using either the arc or 500 candle-power tungsten lamp, in cases of both acute and sub-acute inflammation of the gallbladder, congestion of the liver and other abdominal viscera from chronic malaria, alcoholism and persistent intestinal auto-intoxication. It is no exaggeration to say that my results have been far better than when sole reliance was placed upon customary medicinal treatment.

In the treatment of muscular rheumatism, neuritis and even the intense discomfort associated with herpes zoster (shingles), more rapid and lasting relief, due to diminished congestion and nerve sensibility, will be obtained by this method than by recourse to the various analgesics and with no risk of undesirable after-effects.

The pain in acute middle ear catarrh (common earache), the frontal or orbital headache accompanying acute colds, and especially involvement of the frontal sinus and ethmoid cells is promptly alleviated by a thorough application at frequent intervals of light from a 50-candle power carbon or tungsten lamp in a suitable reflector. To this I can testify not only from my own experience, but I could add the testimony of many physicians familiar with the use of this potent therapeutic agent. In chronic ear trouble and disease of the frontal sinus and antrum, it has proved a very valuable auxiliary by relieving the congestion and clearing up the discharge.

It has been my privilege to witness the success of this treatment in several cases of catarrhal appendicitis, and it has seemed to me that the pain and other symptoms were more quickly ameliorated and the necessity of surgical intervention more often avoided than had been my previous experience.

In various types of septic conditions, such as phlebitis, so-called milk-leg, following child birth, or intrapelvic operations, the use of light in the manner indicated or by means of the multiple light dome, as employed in the Women's Hospital in New York, has proved a well-nigh indispensable agent in gynecological practice.

It will be found equally useful in the treatment of infected wounds of the extremities, cellulitis, furuncles, varicose ulcers, and localized infective processes in general.

From experience up to date there seems to be a brilliant future for this measure in hastening repair in cases of delayed union of fractures.

In an article published some time ago I reported observations which showed that it might be possible to prevent the occasional deleterious effects of the X-ray by following its application with the rays from a marine searchlight. It is very gratifying to me to state that subsequent experience has seemed to confirm these results.

*A paper read at the eighth annual convention of the Illuminating Engineering Society, Cleveland, O., September 21st-24th, 1914, and published in the Transactions.

NEW BOOKS, ETC.

Our Navy and the Next War. By Robert Wilden Neeser. New York: Charles Scribner's Sons, 1915 12mo.; 205 pp. Price, $1 net.

Here is a timely work, which, after careful perusal, we most cordially recommend. The author sets forth the present conditions in our navy, points out its deficiencies, shows the directions in which it should be improved and strengthened both in material, personnel and administration, and closes by giving the general recommendations of the General Board of the Navy made to the last Congress. Mr. Neeser is admirably qualified for the task which he has performed so well in this volume. An enthusiast on naval matters, he is possessed of probably one of the finest private naval libraries in the world. He is thoroughly familiar, not merely with existing conditions in the navy, but with the whole of its thrilling history from the date of its foundation. To this he adds the advantage of an unusually lucid and forceful literary style—too often lacking in modern literature—and largely to this fact is to be attributed the charm and interest which holds the reader's attention closely throughout the volume.

Particularly forceful and greatly needed in the present hour is that portion of the book which is devoted to showing the relation of naval power to national policies—a subject upon which the American citizen, and particularly his representative in Congress, needs to be very thoroughly instructed. There is doubtless a growing feeling throughout the country that, although we have some very fine ships manned by efficient and enthusiastic seamen and commanded by officers second to none in their profession, there is yet something very seriously wrong with our navy. Mr. Neeser points out with great lucidity and strong emphasis just what the troubles are and where they lie. At the present time when there is such widespread interest in the subject of our defense, his work will serve admirably as a textbook and reference book for schools, colleges, debating societies, writers and speakers who are seeking for definite information on a subject of vast national importance.

Indoor Games for Children. Written and illustrated by Gladys Beattie Crozier. London and New York: George Routledge & Sons. 16mo.; 120 pp.

This is a delightful book for children, illustrated from actual photographs showing children playing the games. We find such interesting chapters as: An Impromptu Nursery or Schoolroom Masquerade, including Santa Claus, a Scarecrow, a Cowboy, a Fireman, Peter Pan, Charity Girl, Cave Man, a Spook, Pirates, a Dunce, King Henry V., Brunhilda. While the book is an English one, the games can be played anywhere by children irrespective of nationality. The chapter devoted to "Living Statuary Tableaux" is an excellent one. It is a book which will be welcomed by all children.

Nathan Hale, 1776. By Henry Phelps Johnston, Professor of History in the College of the City of New York. New Haven: Yale University Press, 1914 8vo.; 296 pp.; illustrated. Price, $2.35 net.

Of Hale's correspondence and papers there are known to exist about 70 pieces, of which 64 are represented in this enlarged edition of Henry Phelps Johnston's work. Ten of these are letters written by Hale himself. His home and his ancestry, his four years at Yale, and his experience as schoolmaster, bring us to the Lexington alarm. There are vivid glimpses of camp life and of engagements with the enemy. Hale's movements in that desperate enterprise within the British lines are for the most part shrouded in the secrecy such enterprises demand, but the author allows himself some interesting and plausible conjectures. Then there flashes before us that sinister announcement from the British Commander-in-Chief—a spy executed, and that spy Hale. The latter half of Prof. Johnston's history deals with the preservation of the patriot's memory, the substantiation of places and sites of importance, his alleged betrayal, and the correspondence and papers before mentioned. Altogether the volume is a fitting resuscitation and embodiment of those memories that once were the man who "would have made a soldier after Cromwell's own heart—an Ironside who could pray mightily and fight as he prayed."

Lehrbuch der Meteorologie. Von Dr. Julius von Hann, Professor an der Universität Wien. Dritte, unter Mitwirkung von Professor Dr. R. Süring, Potsdam, umgearbeitete Auflage. Mit 28 Tafeln und 4 Tabellen, sowie 108 Abbildungen im Texte. Leipzig: Verlag von Chr. Herm. Tauchnitz, 1915. 4to.; xiv, 847 pp. Price, 36 marks.

The third edition of Hann's great "Lehrbuch" has been appearing in parts since January, 1914, and is now complete. Thus the misgivings that most meteorologists must have entertained as to the possible effect of the European war upon the later stages of this book's production are now happily dissipated. Julius Hann, although chiefly a collector and digester of other men's work rather than an original thinker, undoubtedly occupies the most prominent place among living meteorologists. His "Lehrbuch" is the work to which every meteorologist instinctively turns in order to ascertain the state of contemporary opinion upon any question relating to the atmosphere. Whereas the average scientific textbook gives the impression that the science of which it treats is in a more or less "finished" condition, Hann presents a true picture of meteorology as a body of knowledge in the making—bristling with unsettled questions, the various tentative answers to which are submitted to the reader, together with copious references to fuller discussion of these mooted points in other books and the scientific journals. This work is, therefore, above all a bibliography—but a most carefully selected and arranged bibliography and collection of abstracts, constituting a "short cut" to the contents of a meteorological library. The first edition of the "Lehrbuch" was published in 1901, and a second, somewhat more condensed in order to make it more convenient for use in the class-room, in 1906. The third edition, we are glad to note, reverts to the scope of the first, which it exceeds in size by about 40 pages. That this work demands prompt notice in the SCIENTIFIC AMERICAN SUPPLEMENT and journals addressed primarily to specialists in meteorology and kindred sciences, is due to the fact that every well-regulated library, personal or otherwise, ought to include at least *one* general treatise on atmospheric phenomena, and, provided its language is not a barrier, Hann's "Lehrbuch" is undoubtedly the book to be selected: just as the same author's "Handbuch der Klimatologie," a third edition of which, in three volumes, was published in 1908-1911, has no serious competitor for first place among general works on climatology and climatography. As to the language, it may be said that persons of English speech find Hann's German exceptionally easy. The collaboration of Dr. Süring, who is Hann's colleague in the editorship of the *Meteorologische Zeitschrift*, has strengthened the portions of the work dealing with the rapidly expanding subjects of aerology (upper-air research) and atmospheric electricity, and also the section on the forms of clouds. Typographically the book is as admirable as the average German textbook. Hann's Meteorology has one serious fault, which it shares with his Climatology; it is quite inadequately indexed. In this respect it is almost as bad as some of the best scientific books emanating from France. However, copiously and rationally indexed books are so rare, in any language, that they may be regarded as bibliographic curiosities.

Reptiles and Batrachians. By E. G. Boulenger, F.Z.S., Curator of Lower Vertebrates in the Gardens of the Zoological Society. New York: E. P. Dutton & Co. 8vo.; 278 pp.; illustrated. Price, $6 net.

Mr. Boulenger's work offers a delightful browsing ground to the naturalist. The reptilian section of the London Zoological Gardens is unsurpassed, and its curator is as fortunate in his environment as the Zoological Society is in its curator. In his comprehensive volume, "Reptiles and Batrachians," Mr Boulenger discloses to us the treasures under his charge, but instead of leaving us to wander blindly and for the most part fruitlessly among these zoological wonders, we have as guide none other than the distinguished curator himself. Under his tutelage we pursue a well-planned itinerary, and gain more than a glimpse into the classification, the inter-relationships, of the animals we study. Their life histories and their habits are briefly but most interestingly related by our guide, while the photographical skill of Mr. W. S. Berridge, F.Z.S., has resulted in placing before our eyes a wealth of reptilian life in characteristic attitudes and occupations. Infinite patience and great skill must have been the price paid for many of these splendid pictures. As instances we may cite grass snakes emerging from their eggs, the frilled lizard with mouth agape and collar expanded, and a reticulated python, giant of all snakes, in the act of constricting a kid. The skill of author and illustrator, combined with their unusual opportunities for study, has given us a most instructive and beautiful volume.

The Yearbook of Wireless Telegraphy and Telephony. 1914. New York: Marconi Publishing Corporation.

Although a house publication of the Marconi Company and therefore in a certain sense a piece of advertising literature, the Yearbook of Wireless Telegraphy is of value. As might be expected, however, the historical portions not only give the full credit to Mr. Marconi which he deserves, but also fail to mention adequately the work of other pioneers. Thus only the dates of Prof. Herz's birth and death are given. Prof. Slaby is little more than mentioned. In chronicling the award of the Nobel Prize to Mr. Marconi in 1909, it is not stated that the prize was divided between Mr. Marconi and Prof. Braun, although the fact is brought out in the biographical notices, in a five-line item. Particularly good is the compilation of the wireless laws of the various countries. A list of wireless telegraph stations is given, but nothing is said about the systems used. Prof. Fleming has a very fine article on electric measurements in which he discusses some of his own contributions to the art. R. Hinks of Cambridge writes very instructively on wireless time signaling and lays particular stress upon the importance of this service in countries sparsely populated. C. E. Prince describes the application of the radio-goniometer of Bellini and Tosi in the construction of the Marconi compass. The origin of the Marconi C.Q.D. signal is explained by G. E. Turnbull. The wonderful effect of wireless telegraphy in making marine navigation safer is well brought out in another article. A. Gray presents an excellent picture of the development of the Marconi system. A good article is that of R. Sankey in which he explains the physical basis of wireless telegraphy by mechanical processes. It is an article that will make clear much that is now mysterious to the non-technical reader. The work of Prof. Slaby in introducing the principle of resonance in wireless telegraphy is not sufficiently acknowledged in the article on resonance. Erskine-Murray gives a very good review of the present status of wireless telephony. G. Kindersley discusses the development of the wireless transmitter. Of particular interest at the present time is the article on wireless telegraphy for war purposes. Dr. H. Eccles, whose writings on wireless are well known to all amateurs, shows what has been done in long distance transmission. G. Prince gives a fairly good account of the production of continuous waves. It is curious, however, that Prof. Wien should appear as Prof. Wein, which must be more than a mere typographical error, since the name is misspelled more than once. A rather dark reference is made to a new device of Marconi's for producing continuous waves mechanically in ocean wireless telegraphy; no description is given of the method. Slaby's name is not mentioned in the biographical notices. As might be expected, Marconi receives the maximum space of 184 lines. He deserves it. Still, one cannot but help regretting that an annual which is so extremely useful could not be made more useful by being less one-sided.

Carranza and Mexico. By Carlo de Fornaro. With Chapters by Col. I. C. Enriques, Charles Ferguson and M. C. Rolland. New York: Mitchell Kennerley, 1915. 12mo.; 242 pp.; with illustrations and map. Price, $1.25 net.

Don Venustiano Carranza has the distinction of being the only man to revolt successfully against Gen. Diaz, he won his cause and outlived the Diaz administration, to perform, at the age of fifty-five, feats of endurance and valor in behalf of the fifteen million peons who attacked Huerta and his "governmental camorra." The life of Carranza and the complicated problem of Mexico is skillfully unfolded by the author, who makes no concealment of his detestation of Diaz and his "Machiavellian talent." He charges that "great newspaper proprietors in the United States were given concessions" and "offered special inducements" to create a favorable sentiment in behalf of Diaz and his government. In these charges he is not sufficiently specific, but in general his allegations are at least circumstantially set forth. All interested in visualizing the ingredients of the Mexican imbroglio should read his version of conditions behind the scenes. His work has the hall-mark of sincerity, and such fervor as it possesses is not allowed to befog the closely sketched, cumulative details of the narration.

The Future of World Peace. A Book of Charts Showing Facts which Must Be Recognized in Future Plans for Peace. By Roger W. Babson. Boston: Babson's Statistical Organization (Incorporated), 1915. Price, $1.

The director-in-chief of the World Peace Foundation favorably discusses this volume, but wishes that the section dealing with "The Danger of the United States" had been suppressed. It would, on the contrary, be well if this section had been made into a tract and distributed broadcast throughout the land. It is one of the most succinct, sledge-hammer arraignments of our invertebrate national defense that we have seen. The main portion of Mr. Babson's striking work proposes a commercial international federation, an extension of the Hague Court, whose primary object would be the neutralization of trade routes. He suggests that the strength of a nation's representation in this affiliation be based upon its "fundamental fighting strength," as determined solely by its number of adult males able to read and write. The objections to this criterion are so obvious and so overwhelming that it is unnecessary to cite them. The physical culturist on the one hand, and the psychologist on the other, may be depended upon to make their protests heard. The suffragists, the socialists and the progressives will object to a course that would abolish war only to substitute cancerous intrigue; and finally the United States as a whole would reject a classification that listed them as third in this commercial federation, even if the United Kingdom had no objection to being relegated to fourth place. However, these criticisms apply only to the suggested plan of representation, and not to the central idea. As a whole, Mr. Babson's work is keen, clear-visioned, and most instructive as to present actual conditions. His charts place both comforting and discomforting facts bluntly before the reader, and his tractate adequately opens up a question that must slowly proceed to a solution, if not to the author's solution.

Drake's Telephone Handbook: A Book for the Practical Man. By David Penn Moreton, B.S., E.E. Chicago: Frederick J. Drake & Co., 1915. 16mo.; 298 pp.; illustrated.

The ten chapters of this manual carry much solid information for the practical man. They undertake to explain electromagnetism, alternating current, the measurement of resistance and capacity, magneto and common-battery systems, and line construction. A chapter on sound is included in order that the student, by understanding its basic qualities, may the better appreciate the problem of the telephone engineer. The final chapter is devoted to telephone troubles and the methods of finding and remedying them; it also offers a set of regulations for the guidance and government of employees.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, APRIL 17, 1915

Charles Allen Munn, President
Frederick Converse Beach, Secretary
Orson D. Munn, Treasurer
All at 233 Broadway, New York

Entered at the Post Office of New York, N. Y.
As Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year . . . . [illegible]
Scientific American (est. 1845) " . . . . [illegible]
American Homes and Gardens " . . . . [illegible]

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We beg to advise our readers that we have discontinued selling numbers of the SCIENTIFIC AMERICAN SUPPLEMENT dated earlier than January 1, 1914. We removed the first week in April to the Woolworth Building, New York city, and the change in our offices precluded the carrying of issues of the SUPPLEMENT extending over a period of nearly forty years. It was, therefore, necessary to turn over this portion of the business to someone who has space for carrying so large a stock. The H. W. Wilson Company of 39 Mamaroneck Avenue, White Plains, N. Y., have been chosen to take care of our back number business. They have the complete stock and are ready to supply any of the back numbers at the standard price of 10 cents. We, therefore, request that, in future, all orders for SUPPLEMENTS be sent direct to the H. W. Wilson Company instead of ourselves. Please do not order SUPPLEMENTS on letters ordering subscriptions for the SCIENTIFIC AMERICAN or the SCIENTIFIC AMERICAN SUPPLEMENT or books, or containing any other matters.

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Publishers of the SCIENTIFIC AMERICAN.

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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SCIENTIFIC AMERICAN SUPPLEMENT

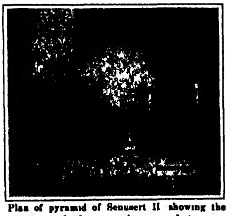
VOLUME LXXIX NUMBER [illegible]] NEW YORK, APRIL 24, 1915 [10 CENTS A COPY $5.00 A YEAR

A wooden hoe

The granite sarcophagus with broken lid plundered by those who took everything from it but did not find the treasure in a recess close to it On right box of jars

Rollers for moving stones

Obsidian jars for ointments, with gold mounts.



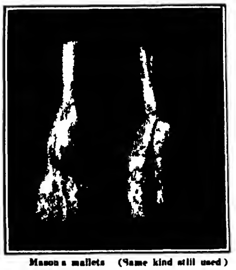
Plan of pyramid of Senusert II showing the positions of the sarcophagus and treasure recess which yielded the remarkable finds.

The pyramid in which the treasure of Lahun was found

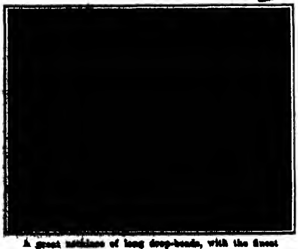
Limestone lamps of pyramid builders

Live ducks

Dead ducks

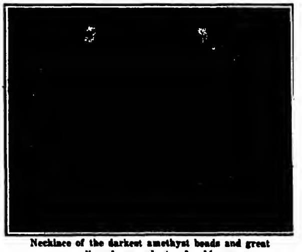


Mason's mallets (Same kind still used)



A great necklace of long drop-beads, with the finest Scarab known.

Silver mirror with Obsidian handle



Necklace of the darkest amethyst beads and great lion claw pendants of gold.

THE BEAUTIFUL ART TREASURES OF LAHUN, OVER THREE THOUSAND YEARS OLD, RECENTLY FOUND IN THE PYRAMID OF SENUSERT II.—[See page 265.]

Electro-Culture*

A Resumé of the Literature and Summary of Facts from Scattered Sources

The scientific literature of the last ten years has contained frequent references to the art of increasing plant growth and yield by the application of electric stimuli of certain kinds, an art most commonly designated as electro-culture. The material given, however, represents very little experimental work in proportion to its volume, consisting in the main of more or less complete historical reviews concluded by a few paragraphs describing some recent investigation. The effect upon a reader desiring to become acquainted with the work done within a reasonable length of time is irritating, to say the least. In view of the growing interest in intensive methods of agriculture, and also in methods of filling in the valleys in the load curves of central stations, there is reason to expect a much more exhaustive investigation of this subject in the not remote future. For this reason it has seemed desirable to collect the facts from the scattered sources, and attempt to arrange them in a form more convenient for use, that is, from the point of view of the invader of the province rather than the historian.

It has been found that the experiments of the past fall naturally into five classes, differing principally in the method of application of electrical energy. These methods are:

I. Illumination by electric light.

II. Conduction of atmospheric electricity from an elevated collector to an electrode in the soil, or to discharge points above the plants.

III. Constituting the soil the electrolyte of a voltaic cell by burying in it two plates of dissimilar metal connected by a conductor.

IV. Passing current from an external source through the soil between electrodes buried therein.

V. Production of a silent or glow discharge through the air from overhead antennae to the soil.

These methods will be taken up in the order given, which is approximately that of their importance.

METHOD I.

Illumination by Electric Light.

There seems to have been relatively little work done upon the effect of illuminating plants by artificial or electric light. In 1861 "Herve" Maugon found that electric light influences the formation of chlorophyl in a way similar to that of sunlight. That the absorption and assimilation of carbon dioxide occurred as usual under the electric arc was shown by Prillieux eight years later.

In 1880 Wilhelm Siemens confirmed these observations, but found that under certain conditions injurious effects were obtained and hence he used an opalescent glass shade over the light.

These facts were further confirmed by Schraler in 1881, and by Bailey, Cornell University, in 1891. Bonnier in 1892, and Couchet in 1901, studied the structure alteration in plants and the leaf growth in relation to the electric light.

Since 1891 this line of attack has been neglected, probably because of the attention attracted by the work of Lemström, and the success of his method.

Dorsey, however, in 1914, mentions the treatment of hot-house radishes and lettuce for three hours each day beginning at sunset, with red light from a 100-watt lamp, and with blue light from a Cooper-Hewitt lamp. The lettuce was affected favorably, the radishes unfavorably.

METHOD II.

Condition of atmospheric electricity from an elevated collector to an electrode in the soil, or to discharge points above the plants.

Among the earliest attempts to apply atmospheric electricity to plant culture appears to have been that of Abbe Bertholon, in 1783. He called his apparatus the electro-vegetometer. It consisted of a number of metal points similar to a lightning rod, supported at a considerable elevation, and connected by a conductor to an iron bar furnished with discharge points which hung down just over the plants treated. The whole apparatus was insulated by wooden supports. The Abbe stated that the use of this arrangement always produced an increase in the fertility, vigor, and growth of the plants.

Later, 1879, Grandeau and his pupil LeClerc showed by careful comparative measurements, analyses, etc., that protection of plants from atmospheric electricity by enclosure in wire cages often retards the growth over 50 per cent. But Naudin repeated his experiment a little later with results diametrically opposite. The more recent experience of Pinot de Moira appears to substantially agree with that of Grandeau.

A modification of Bertholon's method called the geomagnetifère system has been quite commonly used in France. This consists of an elevated conductor connected to wires running through the soil under the plants to be influenced.

Berthelot carried on considerable work at Meudon in France. He found that the growth of plants on the top of a 28-meter tower was greater than at the foot.

Lieutenant Basty experimented with metal rods terminating in a ball of non-oxidizable metal at the lower end which was buried in the ground as deeply as the roots of the plant were likely to penetrate and projected from 2½ feet and 6½ feet above the surface, depending upon the plant treated. The first height was used for strawberries. He claimed that beneficial results were noted about each rod for a radius equal to half the height.

METHOD III.

Constituting the soil the electrolyte of a voltaic cell by burying in it two plates of dissimilar metals connected by a conductor.

Speschnew in Russia obtained marked results from plates of different metals buried in the ground connected by wire.

More recently, 1906, Rawson and Le Baron have used the same method in greenhouses. Plates of copper and zinc were sunk at opposite ends of lettuce beds and gave a potential difference of 0.5 volt and current of from 0.4 to 15 milliamperes. The lettuce thus treated was ready for market a week sooner than that not treated.

Priestly tried the method of Speschnew, using plates of copper and zinc between which beans were planted. The plants treated appeared two days earlier, developed more rapidly, and the average size and weight of the mature beans was about a third greater. Some other qualitative experiments were inconclusive. The current in very damp soil was 12 milliamperes between plates of 200 square inches, 4 feet apart.

Newman, however, states that the results of a dozen experiments indicated no effect whatever, and that the reports of others have been in confirmation of this fact.

METHOD IV.

Passing current from an external source through the soil between electrodes buried therein.

This method of plant stimulation has been the source of numerous conflicting reports, and its applicability seems still to be in doubt. A number of investigators have found that it increases the rate and proportion of germination.

E. H. Cook states that this is the only effect that he was certain was produced by currents of 100 milliamperes at 20 volts.

Kinney in 1898 and Ahlfvengren in 1899, confirmed his results. The former considered 3 volts the optimum, but the latter believed this to vary for different plants, and, under different conditions, for the same plant. Lewenhers's conclusions also agreed with the above, but he considered also that the direction in which the current traversed the seed was of importance.

Kövessi, 1912, on the other hand, as a result of over 1,100 pot tests, came to the conclusion that direct currents through the soil are without exception harmful both to germination and later growth. Schneckenberg, commenting upon this paper, remarked that he ought to have known this fact from a knowledge of the simple laws of electro-chemistry and endosmosis before performing the 1,100 experiments, but goes on to point out that Kövessi's statement should read "horizontal direct currents through the soil" and must not be extended to cover any other type of electrical treatment. Kövessi does not state what strength of current he employed.

Gerlach and Erlwein, 1910, describe experiments with low potential direct current, 6 volts, 0.2 to 0.4 ampere, at Bromberg, upon an area of 914 square feet planted to barley and cabbages. The treatment was continuous night and day until harvest. No beneficial effect was obtained.

Peaslee, 1910, using direct current in greenhouse experiments on the germination and rate of growth of seedings, such as cauliflower, cabbage, beets, etc., experienced failure until he lowered his current density and adopted carbon electrodes, which, unlike some metals, do not react with the soil to form deleterious salts. He obtained the most favorable results at a power consumption of between 0.5 and 0.6 watt per cubit foot, which gave increased fertility of seed, more rapid and vigorous development, and increased size of plant, especially of the root. In the case of a cauliflower, the advantage in respect to growth was nearly 150 per cent. Radishes carried through to a marketable size had a root growth 403 per cent, and a top growth 117 per cent greater than the control[1] plants.

Similar tests with alternating current were consistently negative again until the watts per cubit foot were reduced to 0.0114 (current = 0.000034 ampere per square inch when an increased fertility of 50 per cent and an increased growth of 32 per cent was obtained.

Dorsey, 1913, tried some greenhouse experiments, using direct current (1.5 volts and 0.0008 to 0.07 ampere, and 3 to 8 volts and 0.0007 to 0.05 ampere) and also 60-cycle alternating current, 110 and 220 volts between carbon electrodes. The results were bad in both cases. The temperature of the treated beds was a degree higher than the controls.

It is evident that the investigation of this type of electric treatment has been entirely insufficient to lead to any trustworthy conclusions. The controlling factors have scarcely been indicated as yet.

METHOD V.

Production of a silent or glow discharge through the air from overhead antennae to the soil.

The stimulation of crops by a discharge of electricity through the air to the soil seems to be the method best founded upon theory and most promising in practice.

Prof. Lemström of Helsingfors University, Finland, first remarked upon the fact that the extraordinarily rapid and fruitful growth of such vegetation as survives the frosts in the Arctic and sub-Arctic regions cannot be accounted for, as has been suggested, by the long hours of daylight. It has been proved beyond doubt that there exist in the atmosphere of these high latitudes much stronger currents passing to the earth than is the case further south. These are evidenced by their luminescent effects, such as the aurora. A great proportion of the vegetation, especially that peculiar to northern regions, is equipped with pointed leaves, etc., which are especially adapted to electrical discharge. Moreover, in studying sections of fir trees, Lemström found a periodicity in the occurrence of especially large growth which is the same as that of the occurrence of sun spots and auroras, i. e., every ten or eleven years.

He suspected that the electrical influence played a part hitherto overlooked in the growth of vegetation in other parts of the world. With this in view, he tried to reduplicate the conditions of the Arctic by producing a similar electrical tension in the atmosphere. He applied a positive potential from an influence machine, of which the negative was grounded, to a wire between suspended above the plants, producing a silent discharge to the earth.

Lemström extended his researches to different farms in Finland and, in later years, to other countries. The procedure was tested under his supervision at Durham College, England; in Burgundy, near Breslau in Germany, and at Atvadaberg. His book contains full details as to the extent, circumstances, and results of all these experiments. As a result of his experience he concludes that the minimum increase in yield for all crops under the proper conditions should be about 45 per cent. For certain crops it may rise as high as 100 per cent. Improvement occurs whether the network be charged positively or negatively to the soil, but better results were obtained in the former case. The effect is not apparent alone in the quantity, but an improvement of quality, and a shortening of the period of growth, sometimes by 50 per cent, is general. Analyses are given to indicate that in the case of grain there is an increase in the proteid content. Lemström points out that lack of uniformity in cultivation, nature of soil, and fertilization between the experimental and control plots often leads to erroneous conclusions. The better cultivated and fertilized a field is, the larger the percentage increase in yield due to electro-culture.

Lemström's procedure suffered from a great disadvantage. His influence machine was quite inadequate for the purpose, hence his overhead wires could not be hung more than 16 inches above the plants, which interfered with economical cultivation of the soil.

At Gloucester, experiments with a somewhat more powerful machine, enabling the elevation of the wires to 5 feet above the ground, gave results with various crops as follows:

Beets, 33 per cent increase; carrots, 50 per cent in-

* *General Electric Review.*

[1] The expressions "control," "control plants," etc., are used in this article to signify comparative experiments carried on simultaneously under the same conditions, but without electrical stimulation.

crease; turnips, increase not quantitatively measured.

The beets raised under electrification gave on analysis about 14 per cent more sugar than the control crop.

This increase in sugar content has been confirmed by almost every investigator, irrespective of whether his results were favorable to the process in other ways.

In 1904, Newman performed some similar tests with a small Wimshurst machine driven by an oil engine, operating upon 15 greenhouses, and upon an area in the open amounting to about 1,000 square yards, including control plots. The wires were strung about 16 inches above the plant tops, and were furnished with downward directed points of fine wire for discharge points.

The treatment was applied for a period of 108 days, 9.5 hours daily, the first half of the time mainly by day, the last half by night. The results from the electrified plants were as follows:

Cucumbers, 17 per cent increase; strawberries, 5-year plants, 36 per cent increase; strawberries, 1-year plants, 80 per cent increase, and produced more runners; broad beans, 15 per cent decrease, ripened 5 days sooner; cabbages (spring) mature 10 days sooner; celery, 2 per cent increase; tomatoes, no effect.

The cucumbers were all affected by a bacterial disease about the middle of their growth, and this made much greater headway on the non-electrified plants. Aside from the troubles with the influence machine and oil engine, which were rather inadequate, the installation required no attention except for the clearing away of cobwebs and stray shoots, etc., from the network.

This work was continued on a larger scale, Newman working in conjunction with Sir Oliver Lodge. The latter overcame several of the inherent difficulties of the process by the invention of a mercury arc rectifier supplying a 100,000-volt direct current. The new installation consisted of an oil engine and dynamo producing 3 amperes, at 220 volts, which was transferred by an induction coil and then rectified.

This higher potential made it possible to raise the conducting network to 16 feet from the ground, thus permitting of easy cultivation without lessening the beneficial effect of the current.

Preliminary experiments upon wheat at Gloucester having been very favorable, Newman subjected 11 acres to treatment. The overhead network consisted of stout telegraph wires mounted upon poles in rows 102 yards apart, the distance between successive poles being 71 yards, and thin galvanized wires stretched 12 yards apart crosswise to act as discharge wires. A difference in the rate of growth was noticeable very early, and at harvesting the straw averaged from 4 to 8 inches taller, and the Canadian wheat ripened 3 or 4 days sooner. The yields were 39 per cent better for Canadian wheat, and 29 per cent better for English. Further the electrified wheat sold for 7.5 per cent better price on account of its superior quality.

Breslauer, who has written a critical review of the subject up to 1910, and kept in close touch with the progress of the work in Germany, tells (1909) of the results obtained at Halle by Kühn, and at Holstein, Neumark, and Westpreussen.

At Halle experiments were made under various conditions of fertilization and irrigation upon a total area of about 14 acres, besides the control areas. This field installation was also raised to 16½ feet above the ground. The good effect upon rye was already noticeable in June. It was observed here especially that when the wind blows the effects of the treatment are felt from 10 to 16 feet and sometimes 50 feet beyond the limits of the field experimented upon, and whenever the control fields are adjacent, reduces by so much the apparent improvement due to electrification. This wind effect was also noted in work at Holstein.

After the completion of these experiments, a year later, 1910, Prof. Kühn, the German "Nestor of agriculture," under whose immediate supervision they were conducted, was not enthusiastic as to the results. He stated that little was to be expected from the English procedure, as the advantage apparent during growth did not appear in the yield. His control fields of grass and grain gave the better results. Only fodder and sugar beets were bettered, the latter indeed having an increased sugar content. Clover and cabbages gave uncertain results. He considered that the cost would demand at least a 15 per cent increase in yield.

Breslauer concludes that the investigations already made show that the process and apparatus is entirely practicable. He estimates the cost of an equipment for 61.8 acres as follows:

Generating apparatus	$595.00
Field equipment	595.00
Power consumption, 5 kilowatt-hours per day (at 5 cents) = 25 cents, for season, 150 days =	37.50
Interest on $1,190.00 at 5 per cent	$59.50
Sinking fund at 7 per cent	83.30
Repairs at 2 per cent	23.80
Power	37.50
Labor (1 man 2 hours a day)	47.00
Total	$251.70

Medium to poor yield from wheat: 2,000 pounds per acre:

For 61.8 acres	$2,380.00
Thirty per cent increase	714.00

Profit $714.00—$251.70 = $462.30.

Ordinary profit from 61.8 acres = $71.40.

In a later contribution Breslauer describes the measurement of current and power consumption by typical installations at Hoppegarten.

A movable coil ammeter of great sensitiveness was inserted in the ground wire. The order of magnitude of the voltage was determined by measuring the length of spark in the air, it being known that between balls of 25 millimeters diameter it requires about 3,000 volts per millimeter to produce a spark.

In dry, and not extremely hot weather, with an east wind, the voltage averaging about 65,000 volts, he estimates that, allowing for a certain inequality of distribution, the current for every 10 square feet is about 0.43×10^{-3} milliamperes.

Hence the energy consumption is about $0.26.10^{-3}$ amperes × 65,000 volts = 17 watts = $0.28.10^{-3}$ watts per 10 square feet.

This is from 1,000 to 10,000 times the transfer of electric energy occurring naturally during a year, as estimated by Kähler.

Gerlach and Erlwein give an account of agricultural experiments upon the Kaiser Wilhelm Institute of Agriculture Experimental Grounds at Mocheln for which the equipment was supplied by the firm of Siemens & Halske.

The electrical treatments included high tension static electricity, making the net positive in some cases, and negative in others, and high tension, single-phase alternating current.

The network consisted of a heavy galvanized wire supported on well insulated poles around the outside of the field, and suspended from this, across the field, thin galvanized iron wires at a height of 20 feet.

The electrical equipment consisted of a 4 horse-power alcohol motor belted to a direct-current dynamo, and a transformer. The two influence machines were run by direct-current motors.

The experimental plots comprised an area of 800 square yards besides control plots of one-half this area located at a distance of 330 feet. The plots were treated with various kinds of fertilizer, some were irrigated and others not.

The alternating-current antennae averaged a voltage of about 20,000, the static antennae 30,000 volts. The power consumption for the former was about 770 volt-amperes, for the latter about 30 watts. The irradiation was begun after planting, and continued 45 days continuously day and night. No difference was apparent between the electrified and untreated plants, though there was a considerable difference between the watered and unwatered, and between those differently fertilized. Mention is made of the occurrence of a drought. The harvest, occurring 120 days after sowing, showed practically identical yields for treated and untreated plants, with slight evidence of injury by the alternating current.

Höstermann, 1910, used a network of telephone wires from 6½ to 8 feet above the ground and 13 feet apart, and obtained his current from the atmosphere by means of a steel cable 820 feet long, supported by a balloon or by several kites. He estimated, having an instrument reading to only 5 volts, from other measurements, that he got a potential of about 25,000 volts. This method gave him the best results of any, increasing the yield on various crops from 15 to 40 per cent. He found that the atmospheric potential gradient varied with the season, the time of day, the temperature, and the weather, reaching maxima from December to February, shortly after sunrise and just before and during dusk, at low temperatures, and during fog, snow, hail or rain, and especially during thunderstorms.

The conditions under which treatment is applied are important, it being very essential that there should be moisture in the air as irradiation during dry and sunny weather often results injuriously to the plants. The most favorable times for treatment correspond with those of maximum potential gradient, i. e., very early morning and evening, especially during a fog. He points out that the climate of England is especially adapted, and should give good results, especially as the treatment seems to compensate in part for lack of sunshine.

Exclusion of the influence of atmospheric electricity reduced the yield nearly 15 per cent.

Höstermann, also using high potential pulsating direct current from a dynamo machine and transformer found that extended treatment was of little, or injurious effect, but claimed more moderate application increased the yield in some cases as much as 25 per cent.

Stahl, 1911, claims he was able, using electrical stimulation, to bring a crop of corn to maturity after the winter wheat was reaped on July 25th. He used a direct-current potential of about 250,000 volts (600 cycles) stepped up from a 60-cycle, 110-volt line and rectified mechanically. The wires were mounted 8 feet from the ground, and 2 to 3 feet apart. The treatment was applied to 1 acre morning and evening, and the electric bills averaged $2 to $3 per month. A variety of vegetables were treated. All matured much more quickly and resisted drought better. Only qualitative results are given.

Gloede used the treatment in growing flowers and found greatly increased vigor as well as resistance to harmful fungi. In a small outdoor plot 20 feet square he ripened 362 muskmelons from seed in less than 9 weeks, and the fruit was noticeably sweeter than usual.

An installation near Prague, designed by Breslauer, operated upon an area of 80 acres by means of a network of iron wire supported by porcelain insulators upon wooden poles at intervals of 328 feet apart, across which was stretched a network of 0.008-inch wire at a height of 13 feet above the ground. Direct current at 120 volts, 2 amperes, was supplied by means of a mercury interrupter, a transformer, producing 100,000 volts, and a rectifier. The network was always made positive, and the treatment applied only a few hours each day, being always discontinued in case of rain, which caused leakage, and of great heat, under which latter condition the current is injurious. In spite of an unusually dry season yields in some cases double that of the control plots were claimed. Details as to sort of crop and actual yields are not given.

Basty, experimenting on a regimental garden in France claimed good results.

Dorsey applied to small greenhouse beds for an hour night and morning, daily, alternating current of 200,000 cycles frequency, at 10,000 volts from a Tesla machine and transformer, consuming about 130 watts. He used a network of 0.01-inch wire at a height of 15 inches above the bed. He found by weighing representative plants a marked gain amounting to 75 per cent for lettuce. This method gave better results than illumination or earth currents.

He next applied a silent discharge by means of a network of 0.08-inch copper wire, 9 feet above the ground, 15 feet apart on insulators designed for 60,000 volts, to over an acre of garden, using 10,000 to 20,000 volts at 30,000 cycles for 5 hours daily for 2 months and 50,000 volts for 1 month. Interruption of service makes the results only qualitative in value. Almost all of the irradiated plants, including radishes, lettuce, beets, cabbages, cucumbers, turnips, melons, tomatoes and parsnips, gave a better growth than on the untreated acre. Beans and peas were affected slightly, but all the other plants matured at least 2 weeks earlier than the control plants. Tobacco showed a 20 per cent gain.

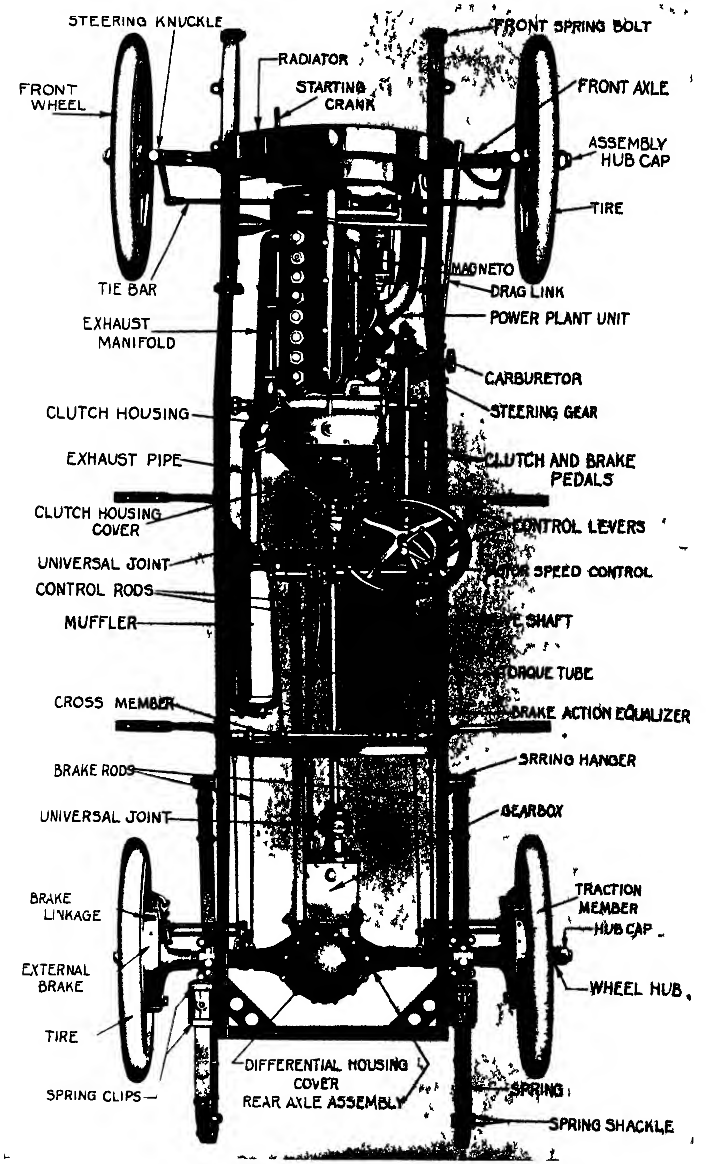
Peaslee, 1913, applied 100,000 volts from a Wimshurst machine on wires 10 inches from the soil to seedlings, with results which he describes as disastrous, at first. Later, by applying the voltage only at night and on cloudy days he increased the growth of strawberries 27 per cent, and beetroots 14 per cent, tops 39 per cent. He could not establish any optimum voltage. He found that the size of the wires made no difference. Climatic variations appeared to have considerable effect.

Preliminary tests with a Tesla coil gave qualitatively similar results.

CONCLUSION.

The impression gained from the literature of electro-culture is that the last word is by no means said. From the nature of the publications it would appear that the individual investigations have been too cursory. There has been too little systematic variation of conditions, and especially of the electrical conditions. It seems highly desirable that a much more extensive investigation, providing the possibility of trying different intensities of electrification under various conditions of cultivation, irrigation, etc., all during the same season, should be carried out. It is significant that the only investigator to attempt an extended examination of the field was able to locate and eliminate many faults in his method, and thus obtain good results in the end in almost every case, often reversing his previous experience. If Lemström, working with his very imperfect equipment and limited resources, could attain so much success, greater development still should be possible with the more adaptable apparatus now available.

The theories as to the actual mechanism of the action of the electric discharge upon plants, involve questions of physiological and botanical chemistry whose answers are still too uncertain to make their consideration here of profit. Lemström, Priestly, Bécard, and Peaslee discuss the subject briefly, and references to points more or less related to it are given in the bibliography appended to this article.



Structural and operating elements of a typical automobile

Buying a Second-Hand Automobile

Defects That Are Apt to Exist and Suggestions for Examination Before Purchasing

By Victor W. Pagé, M.S.A.E.

When one considers the magnitude of the automobile industry and the large number of motor cars that have been manufactured, it is evident that many of these vehicles must have changed hands a number of times since they were delivered to the first purchaser. There is a large traffic in used automobiles and many excellent bargains may be obtained if, before a car is purchased, certain precautions are observed in regard to inspection of parts, especially those portions of the mechanism that are hidden from sight. Neglecting these and accepting the statements made by those trying to dispose of the car regarding the condition of the parts means that one is just as apt to secure a worthless machine as one that will be value for the sum expended.

As all machinery depreciates in service, any used car will have worn parts that must be restored to obtain the full efficiency. The amount of deterioration is not regulated by the service the car has given, but largely by the amount of care that has been expended in its maintenance. A machine operated for several months by a careless driver may show more wear than one used for three or four times that period by a careful operator. One cannot judge the value of the car entirely by its appearance as it is much cheaper to give the body and gear a coat of paint and varnish and to daub the motor with enamel and aluminum paint than it is to give a machine a good mechanical overhauling.

The average person is usually suspicious when offered a second-hand car, as, in the majority of cases, the machine is an unknown quantity. This is especially true if the car has been abused and merely tuned up and "doped" to make a quick sale. After the car has been in use for a very short time, the new owner will begin to experience annoying troubles, some of which may be of a serious nature, necessitating expensive repairs, and naturally the one paying for them may soon expend money enough so that this added to the initial investment would have purchased a new car. The disappointed would-be motorist assumes that motor cars are not yet practical, and does not hesitate to proclaim this fact loudly to all who will listen to his tale, and one such man in a community, especially if he is popular and respected, can materially influence many other probable purchasers of cars. If the car had proved successful, he would have been an enthusiast instead of a pessimist and a distinct help to dealers in his neighborhood. Many reputable dealers recognize this fact, and overhaul all second-hand machines they offer for sale in a thorough manner to make sure that the mechanism is in good working condition, and they will not sell any machine they take in trade unless satisfied that the car will give service proportionate to the investment made by the buyer.

Unfortunately, there are a number of dealers who do not hesitate to palm off any car they may have on hand without making any repairs of a permanent nature. These gentry also are prone to make misleading statements regarding the date of manufacture, power and condition. As they sell on a commission they cannot afford to make repairs, but as false statements are cheap plenty of claims are made that will not be supported by the performance of the machine.

A recital of some of the tricks of the trade may be of assistance to the man intending to buy a used car, and at least will serve to make clear why a thorough inspection is advisable to make sure that expensive repairs are not needed. A capable demonstrator may be able to take out a decrepit antique, and by careful manipulation of the spark and gas levers, slipping the clutch to let the engine speed on hills, avoiding the worn gear ratios in the gearbox and avoiding bad roads or hills, give a demonstration of a car's ability that will prove satisfactory to an unmechanical purchaser, and may sell the car for much more than it is worth.

The writer knows of a number of cases where cars have been sold after a tuning up that failed before the purchaser had run the car a week. One motor in particular that he was called upon to inspect showed how unscrupulous dealers may "doctor" up a worn engine so a satisfactory demonstration can be made. As the operation of the engine in question soon became unsatisfactory, in fact, only a few days after the proud purchaser had driven the car home from the metropolis where he had purchased it, it was dismantled for inspection. When the cylinders were removed it was seen that two of these had been badly scored by running the pistons at some time or other without adequate lubrication. In order to compensate for the lost compression, due to the scratches, a metal plate about 1/8 inch thick had been rivetted on each piston working in the defective cylinders. Badly worn push rod guides had been bushed by wrapping a strip of shim stock around the valve plunger to take up lost motion at that point. The main bearings and connecting rod lower ends had been bushed in a similar manner. In addition to this, the engine had been oiled by a very thick cylinder oil, the purpose probably being to have this cushion the shock due to loose bearings. The fly-wheel was loose on its key, but this had been temporarily held tight by putting in more of the shim stock at the sides of the key.

The transmission system was but little better. After removing a thick grease, impregnated with what appeared to be wood fibers, from the gearset, it was seen that the intermediate and slow speed gears were so badly worn and burred that new ones had to be obtained. In addition to this, the badly worn cone clutch facing had been made to hold by driving in rubber bands between the cone and friction material at all points between the rivets where the leather could be pried up for their insertion. The ball bearings in the gear-box were badly worn; in fact, those supporting the counter-shaft, which was placed under the mainshaft, were so filled with wood particles that the balls were tightly wedged in the separators and just slid around between the bearing races. In demonstrating, the driver had avoided using the gears as much as possible, doing all of his driving on the direct drive or high speed which did not call for rotation of any gears except the constant mesh members, which seldom wear enough to cause noise because they are not clashed into engagement as the shifting members are.

Every point about the car required adjustment, and at every worn bearing point more of the shim stock bushing was found. After the car had been fixed up as it should be, the cost of repairs was about half the total investment in the car. A new model of the same make could have been purchased for less than the final cost after repairs were completed.

There are still some dealers who would be dishonest enough to take advantage of every means to dispose of a car, so a few hints in regard to the points that can be examined with profit may be of value to future motorists contemplating the acquisition of a used car. There are many exceptional bargains offered in used cars which are really desirable. For instance, there is that class of owners who must always have the latest model, even though the car they purchased the year before is still in perfect condition. These cars, if well-known standard makes, require practically no attention to restore them to a satisfactory operating condition. Such cars are of special value to the man who wishes a good car but who does not feel able to pay the price a new model of this kind would cost. Many cars of this nature are sent to the factory or overhauled by factory experts and are sold with the same guarantee that is given with a new car. Such a car is always a good buy, but as they are more costly than those that appear to be equally good offered by brokers and commission men at a lower price, many prefer to take a chance in securing what they think is a bargain.

As a guide to the non-mechanical purchaser, the writer has prepared the accompanying illustration which represents a plan view of a standard chassis, with all points to be mentioned that need inspection clearly indicated. While motor car designs vary, this one is sufficiently representative of conventional design to serve as a chart for systematic inspection of the contemplated purchase. If the car is offered at a very low price, one may be sure that there is some defective condition that makes it desirable for the owner or his agent to unload. As a rule, the second-hand dealers will not permit a buyer to make a thorough inspection of cars they handle if these are not in first-class shape. If permission to look over the car is denied, the would-be purchaser may accept this as positive evidence that there is some defective part it is desirable to conceal and should look elsewhere.

Buying a second-hand car involves an expenditure of several hundred dollars, to say the least, so a purchaser should feel that he has the right to thoroughly inspect any car offered for sale. In fact, it is desirable to pay a skilled, honest mechanic to make the examination if the buyer does not possess the necessary technical skill or knowledge of motor car construction.

The first point to receive attention is the power plant and its auxiliary systems, as this is the most important unit in the car and the most costly to repair if defective. The amount of compression in the cylinders may be accepted as a rough and ready test for engine condition. Turn over the crankshaft slowly with the starting crank, testing one cylinder at a time by opening the compression relief cocks or removing spark-plugs from all except the cylinder to be tested. If the piston does not encounter a positive resistance to upward motion, this is an indication that the engine is not in the best of condition. The valves may need regrinding, which is not a serious fault, or the valve heads may be scored, pitted or warped, a more expensive condition to remedy. The cylinder may be scored, the piston rings broken or stuck or the cylinder bore worn out of round. Rock the fly-wheel slowly back and forth if that member is exposed, to note if there is any looseness in the connecting rod bushings, which will manifest itself by a knocking sound. The skilled mechanic can detect looseness at these points merely by the "feel" at the starting crank. If possible, remove either the cylinder head casting or the bottom plate of the crank-case, preferably both, to examine the engine interior. The connecting rods may be lifted by the hand to detect looseness after the bottom plate is removed and the crankshaft may be tried for looseness of main bearing by placing a jack under the crank webs and lifting on the handle. Depreciation will be indicated by a slight vertical movement of the shaft. Test the valve operating system for wear by noting the amount of lost motion between the valve lift plungers and plunger guides, and in the rocker arms as well if overhead valves are employed. Lost motion at these points may mean a noisy motor.

A good idea of the care the car has received may be obtained by examining the engine for superficial defects such as scars, rust or scratches on the parts. The wiring, spark-plugs and magneto should be examined carefully. The wiring should be in good condition, with the insulation free from cracks and oil deposits. See if the magneto and carburetor are of modern or obsolete design as this will give some indication of the age of the car as will the general engine design. Wear at the various small joints of the control levers will indicate the service the car has given in many instances. Examine the carburetor and note if there is any leakage of fuel from the float chamber which means a defect in that member. Look over all the nuts and boltheads, rods and pipe and notice if the surfaces are marred or edges chipped as by a cold chisel or pipe wrench. If these are bruised it indicates that the car has been poorly looked after, as nothing indicates the careless mechanic more than bolts or nuts that have been turned by a chisel and hammer or a Stilson wrench instead of a properly fitted spanner. Patches on the water jacket show that these have been filled with ice at some time, another indication of carelessness. Note also if parts are held together by proper fastenings or if they are joined by pieces of wire, as wires indicate temporary repairs and lack of thoroughness. Examine the water connections, pump and radiator for leaks, as these also indicate inadequate attention. Test the fan bearings for looseness and look at the fan belt, and if it is oil soaked, cracked and loose, it is further proof of lack of attention on the part of the former owner.

If examination satisfies the inspector that the engine is not in bad condition, have it started and note the regularity of running. If the engine will not slow down it shows that the mixture is defective, this usually being due to air leakage caused by deterioration of the inlet valve stem guides in the cylinders, which condition indicates long and hard service. Note particularly if the engine runs quietly. Knocking sounds are usually due to one of three conditions, carbon deposits in the combustion chamber, mechanical depreciation at bearing points and overheating due to defective cooling or lubrication. If the demonstrator claims the trouble is due only to carbon deposits, suggest that he remove these, which is not an expensive job, and call again later to learn if the knocking has vanished with the carbon. If the radiator steams after the engine has been run but a short time, it shows defects in the cooling system or faulty lubrication. If the exhaust gas is full of white or grayish smoke it shows that the internal engine parts the pistons, rings or cylinders have worn sufficiently to allow the oil to pass through the engine. If the exhaust gas is full of black smoke, this shows an excessively rich mixture. A worn engine will often run with a rich mixture when it will misfire with one of proper proportions. Squeaks denote dry bearing surfaces, rattling shows wear in valve operating mechanism, grinding indicates worn timing gears, hissing denotes compression leaks, whistling sounds leaky packings in crankcase, while a sharp hiss or blowing sound shows exhaust gas leakage at some point. Irregular operation or misfiring usually shows faulty action of the ignition system.

Next in order to the power plant comes the clutch

and gear-box. The condition of the clutch can be best determined when the car is demonstrated. If the engine races and the car fails to move correspondingly fast, it means slipping; if the car starts with a jerk, it shows harsh clutch action due to a charred or stiff clutch leather on a cone, or burred and scored plate surfaces if the clutch is a multiple disk type. If there is any difficulty in shifting gears promptly, the clutch probably does not release completely, this indicating defects in clutch spring thrust bearing or drag between the clutch members at some point. Take the cover off the gear-box and see what kind of grease is used for oiling. If the grease is full of granulated cork or wood fibers, it is reasonable to assume that the gearing is badly worn when recourse is had to such a nostrum to secure quiet operation. Examine the edges of the gear teeth, especially those of the intermediate speed members carefully to see if they are badly burred or worn. The condition of the intermediate gear teeth is a good indication of the amount of service a car has given or the skill of the former operators as this speed ratio is the one most widely used. Grasp the main shaft firmly and try to move it up and down. Any vertical movement indicates wear of the bearings. Do the same with the countershaft. If there is much movement, it not only means that the gearing will be noisy in action but that difficulty may be experienced in shifting gears. It also indicates that new bearings are needed, which means considerable expense if these are of the anit-friction type. Examine also the amount of wear between the shifting forks and the sliding members on the main shaft. This will not be serious unless the car has been used for a long time.

If the change speed gearing is of the friction disk type, look for wear on the fiber wheel as well as on the driving disk. If the fiber is "broomed" over the edges or if the disk is badly grooved, it means slipping and failure to drive positively. If the gearing is a planetary type, examine the linings of the bands. If these are worn and the drums grooved it is a good indication that the gearing has been in use for a long time. A worn planetary gear is also very noisy when the engine is running idly or in low speed ratio.

The usual method of power transmission from the gear-box to the axle drive gears is by shaft and one or two universal joints. Wear at the universal joints can be detected by grasping the shaft firmly and trying to oscillate it. If side chain drive is used on a pleasure car the model is at least four years old. Chains are tested by bending the slack portion sideways to see if the joints are worn. The sprockets should be examined to see if the teeth are worn hook-shape as this indicates extensive use. If the drive is by live axle, jack up that member and test for looseness in the drive gearing by turning the wheels slowly, both at the same time and in the same direction. Lost motion between the wheel hubs and driving shafts, at the gear teeth or universal joints may be easily noted. Turn only one of the wheels, if the other turns of itself in a reverse direction or stands still, the differential gear is functioning properly. If the differential gearing does not work the wheels will turn in the same direction and it will be difficult to retard the motion of either without considerable effort. While the axle is jacked up, it is possible to test the efficiency of the brakes, both external and internal. First pull on the emergency brake lever and try to turn the wheels by grasping the spokes near the rim. The wheels should be absolutely immovable if the brake is holding properly. Release the emergency handle and have some one hold the service brake pedal engaged and repeat the test. Remove the cover from the differential housing and examine the bevel gear teeth, especially those on the drive pinion which wear fastest. If any pieces are broken out of the teeth or the surfaces flaked or rough, new driving gears will be necessary. Also test the differential supporting bearings by lifting up on the differential case with a pinchbar.

In addition to the points enumerated, there are numerous things to inspect about the chassis. Try the steering gear for back lash at the reduction gears, which is evidenced by the degree of lost motion at the steering wheel. Look over the joints at the drag link or tie bar for looseness. This can best be determined by jacking up the front end of the car. Test the steering knuckles for wear between them and the king bolts; also notice the amount of shake in the wheels. If wheel bearings are in good condition, the wheels will turn easily and will have no shake. A badly worn starting handle bearing or worn ratchet teeth on clutch indicates the amount of service the car has received. The rear wheels must also be tested for bearing looseness. The miscellaneous brake rod bearings, control levers, torque members, spring shackles, spring clips and other similar parts may be tested for looseness as great depreciation at these points show that the car has been used for some time.

The condition of the tires, paint, upholstery and accessories must also be taken into consideration. Casings with blow-out sleeves laced on or with patches cemented to their surface are apt to blow out at any time, as are those with deep gashes or bruises or with exposed fabric. If spare casings are included in the equipment and are nicely encased, do not have any compunctions in removing the case to make sure the casing is a good one. An old, wornout shoe fills out a tire case as well as a good one. If the paint and upholstery is in good condition, it may be taken as an indication that the car has received intelligent care if the appearance of the mechanism points to the same conclusion.

Having carefully examined the car, you are ready for a demonstration. See that there is no great difficulty in starting the motor and that it does not vibrate unduly or make much noise. Before going out, insist on having the full number of passengers the car is supposed to carry. Occupy a seat convenient to the driver so you can watch the way the car is controlled. Observe the action of the clutch, see if the car will start smoothly, without jar or noise and if the gears shift promptly and without noise. Note the ease of control, the accelerating qualities of the motor when the throttle is moved and where it is necessary to set the spark lever. If the spark is not advanced much, it means that the driver must nurse the car along. Note if the car is easy riding on rough pavement, not only on smooth roads, and also if it rattles or squeaks when operated at moderate speed over rough highway surfaces. Pick out your own route for a demonstration, taking a variety of roads, some rough, some well paved. Be sure to try the hill climbing ability of the car and note closely the gear ratio required to surmount gradients. If the hill is moderately steep and the car takes it on the high or intermediate speeds, you may be assured it will have power enough for your needs. Have a demonstration of at least 50 miles. Any old car will run around a city block a few times without trouble. Have the gasoline tank filled before starting on the demonstration, and on returning see how much will be needed to refill the tank. This will give some idea of the fuel consumption of the motor.

The more expensive the car, the more thorough the inspection of parts and demonstration should be. Do not buy a big car because it is cheap and appears to be a lot for the money. A white elephant would be expensive to the average man at a cost of one dollar. Do not buy some millionaire's discarded plaything unless you have enough to maintain it, in which case you will not need to buy a second-hand car. If you purchase from a dealer, be sure he is responsible; if from a private owner, be sure he is a bona-fide and not merely a commission man posing as such. Check his claim with the State registration figures. If the demonstration is satisfactory, but several adjustments or some repairs are necessary before the car is in proper condition, stipulate that all of these shall be made before delivery of the car, and do not pay for it until satisfied that the alterations have been made. Take your time in the selection of a car; examine several, weigh their relative advantages and suitability for your use, and if possible patronize some responsible dealer, and your purchase will be entirely satisfactory.

The equitable charge for second-hand cars depends entirely upon the popularity of the make in question. Even the most popular car will depreciate in value about 30 per cent the first year on an average. The two-year old car will have depreciated 50 per cent in that period, a three-year old model should be available at about 40 per cent of its cost when new. After that point a certain rock-bottom value is reached which does not change much as long as the car remains serviceable.

An Inventors' Bank

By Our Berlin Correspondent

The world is indebted for the greater part of its material prosperity to inventors, that is, a class of people who, so far from enjoying universal esteem, are rather treated as Society's step-children. While inventors have done so much for the world, practically nothing has been done for them. How insignificant is, in fact, the slight service tendered by Patent Offices, as compared with the inventor's whole-hearted devotion! Apart from the fact that the frequently inadequate protection must be purchased by pecuniary sacrifices which the average inventor only too often is unable to afford, a patent unfortunately conveys no guarantee of success. Official records go to show that only a small fraction of all the inventions approved by the Patent Office actually find their way into industry, while even of these only a few achieve anything like real success. Though among those nipped in the bud there are many inventions of a perfectly useless description, others doubtless deserved a better lot, and their disappearance means not only the definite end of hope to the hapless inventor, but the loss of considerable, may be inestimable, values to humanity.

While the State spends a great part of its budget in the purely negative endeavor to protect the national wealth against possible attacks from outside, it so far neglects another task of a more positive character, viz., promoting the inventors' work and thus directly increasing the wealth of the nation. Whereas practically all professions find credit with some bank or other, on their produce merchandise, etc., there is so far no banking institute granting its financial aid to inventors, and unless these succeed in obtaining the assistance of private parties, or have some financial means of their own, the way to success will never be open to them.

A Rumanian engineer living in Berlin, Mr. E. Schnürer, has devised a scheme which, if properly realized, might result in the efficient assistance and utilization of inventors' work. According to Schnürer's opinion the German Empire, with a yearly expenditure of 12,000,000 marks, that is, about four per million of its yearly budget as a maximum, could not only afford to all its inventors, in so far as they really deserve it, the possibility of definite success, but at the same time contribute in no small degree to the progress of humanity. This scheme comprises the foundation of an inventors' bank which, in its laboratories, workshops and testing plants, would, at the inventor's request, develop any invention patented in the country, until its practicability or otherwise has been brought out beyond any possibility of doubt, either with or without the inventor's assistance, the latter alternative applying mostly to the case of layman inventors.

A negative result would be reported to the inventor in writing, with all details as to the factors at issue. If, on the other hand, the practicability of an invention has been brought out, the inventors' bank takes all necessary steps to turn it to account, in Germany as well as abroad, to the best of the inventor's interests, by the sale of patents, granting of royalties, or the foundation of special companies.

Of the profit derived from the invention, the bank would draw for itself 40 per cent until all its expenses are reimbursed, plus 8 per cent interest per annum; after which its share in any further profit would be 20 per cent.

Though there be every reason to suppose that the bank, with so liberal a reward for services rendered, would do good business, there might still be some risk for its shareholders, especially during the first few years, on account of the great novelty of its operations. In fact, even the best of inventions take some time to assert themselves; and it would therefore only be just for the State to grant important privileges to a financial institute bound to exert such a beneficial influence on the economical development of the country.

Whenever all of its shareholders pay in a certain sum, the State would have, in its turn, to pay the same amount to the bank, until a total amount of 250,000,000 marks has been thus paid by gradual installments subject to the following conditions:

Of the yearly net profits of the inventors' bank the shareholders would, in the first place, as far as these profits be sufficient, receive as a dividend, 10 per cent of the capital contributed by them. Of the balance the State would be granted one fourth, year for year, until the payments made by the same (250 millions as a maximum) have been refunded, plus 4½ per cent yearly interest. Even after being thus reimbursed the State, however, will keep its right of controlling the business of the bank.

What would be the actual cost to the State of the sums thus granted to the bank? Twelve millions as a maximum per year, for about sixty years, in the most unfavorable case, i. e., if the State should have paid the bank fully 250 millions without receiving anything in return. The State could, in fact, obtain these sums by means of a 4 per cent loan, redeemable after about sixty years. The advantages to be expected from the working of the bank for individuals and the country at large would, however, in Schnürer's opinion, more than outweigh such a sacrifice of 12 millions a year as a maximum.

In drawing up the statutes of the inventors' bank, care would have to be taken for its mode of working to merit unlimited confidence on the part of inventors. This would, among other things, be obtained by the following regulations:

1. No employees and members of the bank should be allowed to patent anything, directly or indirectly, not even within the first five years of his leaving the bank.

2. The bank should under all circumstances work hand-in-hand with the inventor in everything pertaining to the promoting of his invention.

3. In order to avoid any conflict of interests with an inventor promoted by the bank, the latter should never participate (financially or otherwise) in an undertaking liable to engage in the sale or working of an invention promoted by the bank, unless the latter share in the interests of the inventor at the statutory rate of 20 per cent for the bank and 80 per cent for the inventor.

4. The capital and other means of the inventors' bank should be used by the latter not in working or selling inventions, but only in developing inventions and inducing others (capitalists, business men, or industrial men) to work or sell the inventions promoted by the bank to the best interests of the inventor, in whose profit the bank has a permanent share of 20 per cent.

Hour Angle Observation of Polaris by Daylight

By Robert V. R. Reynolds, Forest Examiner 1915

OBSERVATION OF POLARIS BY DAYLIGHT.

It has been recognized by surveyors for a number of years that it is possible to observe Polaris by daylight through the telescope while it is still invisible to the unaided eye. The methods set forth for this purpose have not been used extensively, however, because of difficulties in getting the star within the field, and also in finding it when it is known to be there. The required computations of azimuth and altitude of Polaris are often inconvenient and sometimes uncertain for a busy transitman. It is believed that the previous troubles will be overcome if the following table is used and the subsequent directions noted.

TO FIND POLARIS BY DAYLIGHT.

Add to Latitude for hour angles less than 6
Substract from Latitude for hour angles exceeding 6

Hour Angle of Polaris	Azimuth Setting	Altitude Setting
Approximate* (Use suitable interpolations	NE or NW depending upon position of Polaris E. or W of Meridian	Latitude plus or minus the tabulated quantities
0.0 or 12.0	° 00'	1° 08'
0.0 or 11.5	° 12'	1° 07'
1.0 or 11.0	° 24'	1° 06'
1.5 or 10.5	° 36'	1° 04'
2.0 or 10.0	° 47'	1° 00'
2.5 or 9.5	° 57'	° 55'
3.0 or 9.0	1° 06'	° 50'
3.5 or 8.5	1° 15'	° 43'
4.0 or 8.0	1° 22'	° 35'
4.5 or 7.5	1° 27'	° 27'
5.0 or 7.0	1° 30'	° 18'
5.5 or 6.5	1° 32'	° 09'
6.0 hours	1° 35'	° 00'

*The hour angle used as the argument in this table needs only to be approximate. If it is correct within five minutes sufficiently accurate settings will be indicated provided interpolation is made. Hence there is no need of correcting for longitude until the surveyor has made the observation and is preparing to enter the table of Azimuths of Polaris.

Polaris may always be found in clear weather as soon as the sun has set, and very frequently for five or ten minutes before sunset or after sunrise. It is stated on good authority that under very favorable conditions the observation has been successful as late as 10 o'clock A. M. In the northern United States the cross wires may remain visible for a long time after sunset.

For the novice it is often difficult at the first few attempts to see Polaris while the sky is still bright, but after once having found the star, which appears as a small white dot in the field, he will never thereafter feel in doubt. Granted that the tabulated settings are sufficiently accurate to bring the star in the field, there will still remain several factors which must be given suitable consideration before success can be definitely assured:

1. A slight haziness, which may hardly be obvious to the eye, is sufficient to conceal the star until darkness comes on.

2. The telescope must be in exact focus for celestial objects. This may be accomplished either by focusing at night upon the moon and making a slight scratch upon the objective slide, to show the point to which it should be extended, or the surveyor may focus at the time of observation upon a well-defined object 3 or 4 miles distant, which focus will usually be found sufficiently close. Accurate focusing is one of the most important factors in finding the star, but one that is too often neglected.

3. For the purpose of cutting off objectionable light, the sunshade should always be attached. Additional certainty of finding the star is rendered by throwing a coat or other dark cloth over the head when searching through the telescope, as a photographer uses a focusing cloth.

4. An approximate meridian must be had, from which the azimuth settings are turned off. Commonly the surveyor will already have such a meridian from his backsight. Otherwise, a meridian determination from a solar attachment in reasonable adjustment will suffice. Sometimes, when the magnetic declination is closely known, it will even be possible to turn upon the star from the needle. A reference meridian which is true within 05 minutes or 10 minutes will be precise enough to locate the star when the table of approximate settings is used.

The use of a reference mark is contemplated, such as another station of the survey, or a hub, or a distant, well-defined tree or snag on the skyline. Polaris having been found, the angle from the reference mark to the star should be measured twice, the second time with the telescope inverted. The mean time of observation and the mean angle are then used to find the azimuth of the mark by the simplified hour-angle method. There is practically no chance that any other star will be seen and mistaken for Polaris.

THE SIMPLIFIED METHOD OF COMPUTING HOUR ANGLES OF POLARIS.

The hour-angle method as set forth in the General Land Office Manual of 1902, was too complicated, on account of the required change into sidereal time, to be commonly and confidently used.

The admirable Ephemeris now issued by the General Land Office tabulates, for every day of the year, the Greenwich mean time of the upper culmination of Polaris. The possession of these data in the field makes it possible to easily compute the hour angle of the star at any desired time of observation by simply taking the algebraic difference, in hours, minutes, and length of minutes, between the local mean time of upper culmination and the local mean time of observation. The change into sidereal time is not required.

The following steps are necessary:

1. The tabulated Greenwich mean time of upper culmination must be corrected to the corresponding *LMT* on the meridian of observation by subtracting from it the following correction for longitude:

$$\frac{\text{Longitude}}{360} \; 3.9 = \text{correction.}[1]$$

2. If the star when observed is west of the meridian the corrected time of upper culmination, for the civil date of observation, is subtracted from the *LMT* of observation. If the star when observed is east of the meridian the *LMT* of the observation is subtracted from the corrected time of upper culmination for the civil date succeeding the observation. The result in either case is the exact hour angle of Polaris.[2]

3. Using the exact hour angle as an argument, the azimuth of Polaris is derived from the table of Azimuths of Polaris (Ephemeris pp. 14 and 15), interpolation being also made for the declination of the star and for latitude.

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4.5 or 7.5	1° 27'	° 27'
5.0 or 7.0	1° 30'	° 18'
5.5 or 6.5	1° 33'	° 09'
6.0 hours	1° 35'	° 00'

*An hour angle correct within five minutes is sufficient for the purpose of this table. Hence there is no need to correct the time of upper culmination for longitude until the Azimuth of Polaris is looked up in the Ephemeris.

[1] The approximate difference in length between the day of mean solar time and the sidereal day is 3.9 minutes.

[2] In order to make sure of sufficiently accurate azimuth determinations the surveyor should be certain of local mean time within one minute. This requirement is particularly urgent near the times of culmination, when the apparent motion of the star in azimuth is at its maximum.

The Pottery Industry of the United States

A report on the pottery industry in this country has recently been published by the Bureau of Foreign and Domestic Relations of the Department of Commerce that contains much of interest and also some surprising information in regard to manufacturing and commercial conditions, one of the most remarkable of which is that the potters of the United States are without adequate knowledge of the costs of production in their own industry. This is but the natural result of inadequate cost methods, but why such business methods should exist is difficult to understand.

The industry appears to be in a decidedly healthy condition, for it is stated that from 1901 to 1912 the value of pottery products increased 62.5 per cent and profits ranged from 21 per cent to 7.73 per cent, the latter indicating a loss of 4.68 per cent.

Extreme variations in cost of production were found to exist in different potteries, due in no small part to the different conditions in different plants and to the methods of the manufacturers. The successful manufacturers may be divided into three groups: those who have large kiln capacity and market great quantities of excellent ware that is sold direct to large retailers without the intervention of middlemen; small manufacturers who make a white ware of the best quality, well decorated and selling at good prices; the last class produces "scheme" ware, which is sold at relatively high prices to distributers of coffee, tea, cereals, beer, etc.

Large differences in cost of production were found to exist between the potteries of the United States and those of Europe, the level being considerably higher in this country. In fact (except one establishment in Austria), the lowest cost of production in any American pottery exceeded the highest cost of production in any European establishment. This condition will be understood on an examination of the following figures presented in the report: The cost of all materials and expenses, excepting labor, in the manufacture of white ware in the six representative American earthenware establishments averaged 2.05 per cent higher per 1,000 cubic feet of glost-kiln space fired than the cost in English earthenware potteries, 0.25 per cent higher than in Austrian china potteries, 20.2 per cent higher than in German earthenware potteries, and 17.77 per cent higher than in German china potteries. The labor cost for the same unit averaged 81.8 per cent higher in the American potteries than in those of England, 75.96 per cent higher than in German earthenware potteries, 62.9 per cent higher than in Austrian china potteries, and 138.97 per cent higher than in German china potteries. The total cost of manufacturing white ware in the American establishments was 38.43 per cent higher than in the English potteries, 53.65 per cent higher than in German earthenware potteries, 69.15 per cent higher than in German china potteries, and 30.25 per cent higher than in Austrian china potteries.

One of the reasons for high cost of production in this country results from the poor location and bad arrangement of the plants, which have had a haphazard growth. As a rule American potteries have evolved from small plants, and as business increased poorly arranged additions were made, so that only a few establishments have thoroughly modern plants equipped throughout with up-to-date machinery. Many of the establishments are poorly located in reference to transportation, convenience to their supplies of raw materials, and to their markets. The machinery and equipment in use in American and foreign potteries are fundamentally the same, but the American establishments have been slow to improve working conditions and to increase their efficiency by the installation of some improved devices successfully used in foreign factories, and in many cases it would appear good policy to scrap the plants and establish complete modern outfits in suitable locations.

Competitive prices of American and foreign ware in the United States are not determined solely by the difference in costs of production at home and abroad. Other factors, including customs duties, transportation charges, and incidental expenses, are sufficient to offset the difference in cost of production.

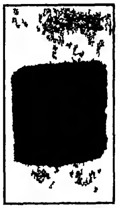
In spite of the fact that the average wages paid in American potteries in the different occupations are higher than those paid in European potteries by from 90 to over 600 per cent, the labor cost per unit of product never shows so great a difference as 82 per cent (except in German china plants). This indicates the greater efficiency of the American workman.

The wages for American skilled workmen in earthenware potteries were from 91.05 to 236.28 per cent higher than in the English potteries, while the cost of labor per unit of product was 81.8 per cent higher in the American potteries. The fact is that, while workmen in foreign potteries receive less in wages than the American, they do not give as valuable a return for their wages. The difference is even more striking in the Austrian and German china potteries. The American wages were from 151.94 to 660.24 per cent higher than in the Austrian establishments, but the labor cost per unit of product was only 62.9 per cent higher in the United States. American wages ranged from 150.99 to 582.8 per cent higher than those in German china establishments, while the difference in labor cost per unit of product was 138.97 per cent. In no case was the difference in average labor cost per unit of product so great as the minimum difference in wages for the same occupation.

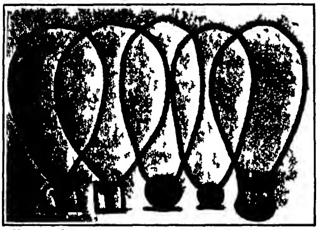
It is expected, however, that the American workman shall provide for himself the many benefits which European countries have arranged for him. Included under the general title of social insurance, the European workman is provided against the contingencies of sickness, especially occupational disease, which is unfortunately prevalent in this industry, and accident invalidity, old age, or death, and in some cases of unemployment.

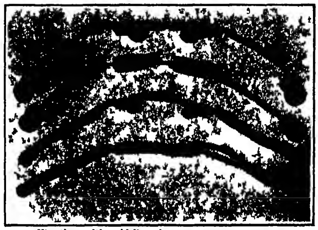
There is a distinct need for more scientific methods of production, which can be brought about only by highly skilled instruction and more scientific research work. There are twenty-two technical schools in Germany and eight in Austria devoted to instruction in ceramics and the development of the pottery industry. England has a number of high-grade schools in which similar instruction is given. In the pottery centers of the United States there are no such institutions, and the average pottery in this country cannot afford to employ a scientific ceramic chemist who is not also a capable practical manager, a combination of qualifications which is rare indeed. The work of the Technical Chemical Research Institute of the German government indicates what might be done in this direction. The practical co-operation of the United States Government, through the Bureau of Standards of the Department of Commerce and other Government agencies, with the manufacturers is accomplishing much in advancing the standard of American pottery.


A great collar of gold cowries

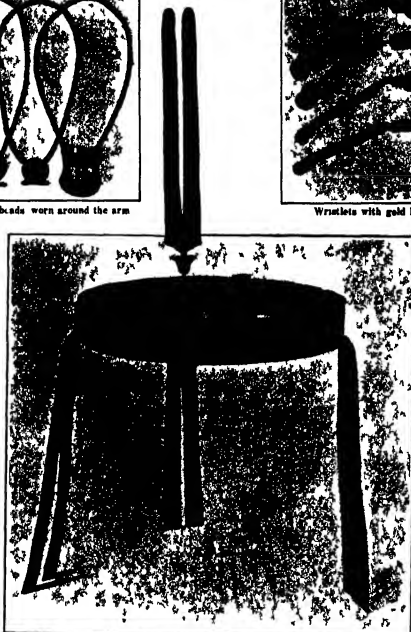

A bracelet with gold bars and beads


Great collar of gold lion heads.


Motto pendants on strings of gold beads worn around the arm


Wristlets with gold lions between strings of beads

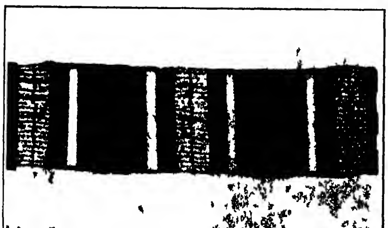

Armlet with name and titles


Crown with plumes of gold and three double streamers of gold


Copper razors with gold handle


Gold pectoral inlaid with stones (Amenemhat III)


Gold pectoral inlaid with stones. (Senusert)


Bracelet open showing the two sliding joint edges.


Armlet of gold bars, with turquoise and carnelian beads.

From the Illustrated London News.

The Treasure of Lahun*

Beautiful Jewelry Ornaments and Tools Found in a Plundered Pyramid

By W. M. Flinders Petrie

A TALL grey pile of brickwork stands high on the desert edge at the entry to the Fayum, some sixty miles south of Cairo. Here was buried a great sovereign of the land with all his family: two hundred generations of the descendants of his subjects have come and gone since then. Nearly all the tombs of Egypt were ransacked in early times, probably within fifty or a hundred years of the burial. This King, Senusert II., had no immunity: his pyramid was entered, his sarcophagus broken open; no trace of his burial remained. Likewise the tombs of his family—all were attacked. Five empty tombs stand along the south side of the pyramid, without a bone left in place. When the British School of Archeology in Egypt began work there last December, a complete clearance was planned to lay bare every inch of the site, and clean the rock, so that no passages or tombs could remain unsearched. In that clearance the five tombs just named were reopened, and entirely cleaned out. Two of these had not even a coffin left. The others had sarcophagi totally bare; everything seemed to have vanished. In one tomb the wide pit descended by back steps in the rock to a depth of about twenty-eight feet, and at the end stood a granite sarcophagus, the lid pushed back as far as it could go, and then bruised and broken away so that a boy could crawl in and destroy the burial. Not a chip of the mummy or its wrappings was left behind. Hours, perhaps days, of work had been spent on thus ransacking the grave. Yet all the time, close by the plunderers' side, was a recess in the tomb which they disregarded. There, so close by that a tall man might have touched the crown with one hand and the sarcophagus with the other, the treasure lay quite undisturbed and unnoticed. After the tomb was opened it stood a yawning pit, gradually filled up by occasional storms once in a few years washing down mud. Slowly the caskets rotted, the vases fell over, the threads decayed, the beads rolled apart, and in perhaps fifty or a hundred years the whole pit was filled with mud and dust, and lost to sight. How such a considerable treasure can possibly have escaped the notice of men who were zealously searching for it, is one of the mysteries of the inexplicable past.

In the midst of the recess lay the crown: the tall plumes of gold and the three double streamers of gold all lay down flat, with the crown between them. They had evidently been carefully deposited, and never disturbed. The crown is a broad band of brilliantly burnished gold, with fifteen beautifully inlaid rosettes of gold around it, and in front of it the royal cobra of gold inlaid, the head of lazuli. This head was missing when the crown first appeared; some days afterward, in washing the earth from the recess, the head was found. Then one eye was missing. I washed and searched minutely, preserving the smallest specks of precious stone. Soon a tiny ball of garnet appeared at the bottom of the bushelful of mud; this—no larger than a pin's head—was the missing eye. Yet the gold socket of the eye was missing. I remembered having washed out a bead of gold which differed from thousands of others; looking, I found it again, and there was the setting of the eye complete. Above the crown at the back of it stood up double plumes of gold, fitting into a golden flower. At the sides and back hung down broad ties of gold. The whole crown is too large for a modern head, being made to go over the very full Egyptian wig; it is altogether over eighteen inches high.

The next most striking objects are the great collars of gold cowries and gold lion heads. These are ingeniously fastened with one piece in two halves, joining together by a slider, so that the collar has to be much contracted before it can open. Two beautifully wrought pectorals are of gold inlaid with minute pieces of carnelian, turquoise, and lazuli. In the pectoral of Senusert there are 372 separate stones inlaid. The harmonious outline of these designs, and the exquisite work, make these the most charming examples of Egyptian gold-work.

A great necklace of long drop beads must have been worn hanging below the other jewelry. The pendants are of gold, carnelians, lazuli, and amazon stone. From the middle hangs the most splendid scarab known, cut with perfect sharpness in the richest lapis lazuli. A larger figure of it is put in the middle. Yet another necklace was of amethyst of the darkest, fullest color, with gold lion claws as pendants.

Armlets were worn of gold bars with minute beads of turquoise and carnelian. They were fastened on the arm by sliding a strip of gold, covered with inlays of carnelian, and bearing the name and titles of Amenemhat III.

Bracelets were of much the same style, only without a loose slider, the edges sliding one into the other. Five little motto-pendants were worn by strings of gold beads round the arm; each pendant has a sliding clasp at the back, to fasten the string of beads.

Four wristlets each have a pair of gold lions, face to face, upon strings of beads of gold, carnelian and turquoise.

The toilet was provided for by a large silver mirror, with a handle of obsidian, and gold head of the goddess Hat-hor; a pair of razors with gold handles; and three jars for ointment made of black obsidian with gold mounting round the base, the brim, and the lids.

The funeral outfit of the sacred oils and unguents was in eight alabaster jars with lids.

The Egyptian government claim half the value of all discoveries, and have retained the crown, one pectoral, and the mirror, in Cairo. All the other objects are in London.

Besides this great group of jewelry, which is the only such treasure that has ever left Egypt, there were many curious things found in the wide excavation around the pyramid. Here we may see two groups of ducks, the one lying dead on an altar with the eyes closed, the other being carried and all alert. These show how minutely the sculptures of the temple were wrought. The first lamps that can be proved to be such by their wicks, were found in the pyramid; they are of limestone with pierced disks of pottery in the central cup, to hold up the wick. Around the cup is a trough to hold water, in order to keep the stone damp so that the oil should not soak away. Of the workmen's tools, there were many mason's mallets, very like those used to-day; wooden rollers for moving the stones, and a wooden hoe.

* Reproduced from the *Illustrated London News*.

How the Science of Preventive Medicine is Minimizing Accidents*

THERE has arisen on the part of good medical thinkers and at the call of an enlightened public, a new medical specialty, the science of preventive medicine. The value of men, women and children in our country is worth in money more than twice as much as are our industries, railroads, land, buildings and improvements. No monetary value can be placed on the health and happiness of humanity.

What has been true of the science of preventive medicine in the past is going to be intensified in the future. Medical sociologists have demonstrated to us the folly of attempting to raise healthy children in the slums. They have shown us the folly of allowing children, our next generation of workers, to reach manhood stunted in knowledge and health by an impossible environment and one that could be controlled.

In many places we are giving our school children a physical examination in our endeavor to find the early traces of disease, and to correct the disorder before the damage is done. Students of the work find that it pays the community in dollars and cents, because they have discovered that a large percentage of the children, who are repeating years in school at an average cost of $20 a year per child, are not doing so because of dumbness and inability to learn, but on account of physical defects that could be corrected.

Recently a new and powerful force has been introduced, which depends upon medical men for its success, and which will do more to alleviate human suffering and economic loss due to accidents and disease, than any previous methods tried. I refer to the activities of the State to classify its accidents, and to place a premium upon their prevention, to teach the truth about occupational diseases and their prevention and to provide the workingman with a healthy place in which to work. I wish to pay tribute to some industrial organizations for their efforts to aid the State in its work, and to their interest in supplementing that work with an accurate knowledge of the physical condition of its workmen, in order that in so far as it is possible no man shall be allowed to do a kind of work that is unsuitable to his physical condition. The very beginning of disease may then be detected long before serious damage is done. This, to my mind, simply is a continuation of the work done, when the school child is physically examined.

What the State's loss of time is, per accident per man, I do not know, but I have learned from experience that for men so badly hurt that a day or more is necessary, the average of 12 days for all injuries should not be exceeded, if the work is most efficiently done. Diminished numbers of infections, with their increased loss of time, 4 days to 1 of the non-infected cases, their deformities and stiff joints, and sometimes amputated members, test the skill, knowledge and efficiency of the medical men. Infections at the Youngstown Sheet and Tube Company, where I have the honor to be employed, number 1 in 914 for all open wounds when treated at once. The ratio of Ohio as reported by Dr. Binkley, chief medical examiner of the State, is 1 in 19, 50 per cent due to the neglect of the injured man himself, and the other 50 per cent to the medical care. Every employer of labor should so organize his forces that care is given the injured man in such a manner as to yield the minimum amount of infections and thus diminish the expense and suffering.

My associate, Dr. Dobbins, and myself, at the plant of the Youngstown Sheet and Tube Company have been engaged for the last nine months in studying the relationship between the physical fitness of men and their working efficiency, as well as the relation of the worker's health to accidents. We feel sure that we see clearly in many cases the relation of poor physical conditions, bodily and mentally, to accidents. The test of such work as this is not how many men we can refuse work or remove from work, but how many it is possible to make physically fit or how many can be placed at work that suits their physical condition.

Under our former system we waited until from physical weakness a man consulted a physician, and was told the cause, while in the meantime he ignorantly exposed to infection his wife, children, and fellow workmen. By repeated examinations we frequently find evidences of incipient tuberculosis, remove the man to a sanatorium for cure, while a cure is possible, stop the possibility of the afflicted infecting his family and fellow workmen, and return him in the shortest time necessary for a cure, to his family, and to society, a useful producer and also a non-infecting individual.

Upon the eyesight of all men depends their own and others' safety. I recently examined a motor crane inspector, who had so little vision that he could not count fingers held at arms length. A little advice and a properly fitting pair of glasses made him an efficient and safe man, besides adding to his own comfort and removing his handicap.

It is eminently not fair to ask a heart case to compete for his living with those of sound heart, for sooner or later, the heart case will become incapacitated and become a burden to his family; a public charge maybe; certainly an economic loss. If placed at work suitable to his heart condition, the man may give good service for years. Hernia, or rupture, usually a congenital defect of nature, has been a potent cause of inefficiency as well as a source of physical disease and absolute danger. I have been obliged recently to operate on two men whose hernias had become strangulated while at work, and required immediate operation to save their lives. It will raise the health and efficiency of men if we place trusses on the suitable cases, and advise operation when it is necessary. Many a man suffers torments from a supposed rheumatism, when in reality he is troubled with flat foot, a condition that if treated with arch supports can be remedied and all suffering removed.

If these methods bring health, happiness and greater safety to the workingman, there is only one way in which the results can be gained, and that is by the frequent examination of all individuals. These same results could be obtained if we would consult our physicians at stated intervals, but we human individuals have not yet learned to spend our money when well, to prevent being sick. Industry is just beginning to learn, that it is worth more to prevent sickness than to wait until "the horse is stolen."

When the proper intimacy between medical man and employee is established; when men are examined, defects found and advice given as to remedy, then exists the opportunity to tell and educate large masses of people regarding sanitary living, proper ventilation of the home, the truth about the seriousness of diseases and how to care for them, as well as how to protect themselves and others from infections.

*Extracts from an address delivered at the Safety Exposition of Ohio held at Columbus by Dr. Sidney M. McCurdy.

Washington-Paris Longitude by Radio Signals*

A Valuable Application of Wireless Communication

By F. B. Littell and G. A. Hill

A PROPOSAL from Capt. J. L. Jayne, U. S. N., superintendent of the Naval Observatory, to determine the difference of longitude between the Naval Observatory at Washington and the Observatoire de Paris at Paris, France, by the use of radio signals from the naval station at Radio, Virginia, and from the Eiffel Tower station in Paris, having been favorably received by the French authorities, preparations were begun by the direction of the Navy Department early in the spring of 1913. The methods adopted were those developed by the French and described in *Détermination par la Télégraphique sans Fil de la Différence de Longitude entre Paris et Bizerte* and other publications.

The longest distance over which the method had previously been applied was in the above mentioned determination between Paris and Bizerte, which distance is about 960 miles, and in order to make sure that the method could be extended to meet the requirements of the present case, the French government sent over a preliminary expedition with four observers in March, 1913. This party was equipped with the astrolabe as modified and improved by Messrs. Claude and Driencourt for the determination of time, and although it was late in the season for successful radio transmission over so great a distance, the party succeeded in securing a sufficient number of radio clock comparisons on two nights to convince them that the radio method would be entirely practicable at a more favorable season of the year.

For the American observers, two new transits were ordered from M. Prin of Paris. They were to be practically duplicates of those in use by the French observers of three inches aperture, thirty-three inches focal length, with self-registering right ascension micrometers driven by electric motor and controlled by hand, reversible on each star, with hardened steel pivots, and electric lighting. A meridian mark and lens of approximately one hundred and fifty feet focal length was provided with each instrument. As it was planned that the work should be done in duplicate by French and American observers working simultaneously, it was necessary to erect two small buildings in the observatory grounds for the shelter of the instruments.

For the second period, all the observers and astronomical instruments were interchanged.

The astronomical programme was to observe from 7:30 P. M. to 1:30 A. M. local mean time at both Paris and Washington. As each star was observed with instrument direct and reversed, the collimation error was eliminated except for a small correction depending on the length of the signals which was applied, the level was determined by the striding level between every two star observations, and the azimuth by means of readings on the meridian marks which were also made between every two star observations. With this programme about five clock stars per hour could be observed. When possible, three or four azimuth stars were observed each night. The observing list for each station was made up so that in any period of three hours the stars were fairly well balanced as to the zenith. Nearly all the stars north of the Washington zenith and south of the Paris zenith were common to both observing lists. The two astronomical observers of each party alternated in observing the first and last half of the evening.

At Washington the Riefler standard sidereal clock sends its signals on the even seconds (omitting for identification the zero second of each minute) to a small break circuit relay which operates a large 7-point break circuit relay which distributes the signals to the various instruments of the observatory. Only one of the seven points being available, it was used to operate a 4-point relay, one of whose points was used to send the clock signals to Radio, one to the French, and one to the American chronograph. As the French chronograph could operate only on a make circuit, and as the American could operate on either, the circuits were arranged as make circuits. By the above arrangement the 4-point relay became practically the observing clock, and it was only necessary to determine the lag of the point used for the chronograph relative to that used to send the signals to Radio. This was done by recording on the chronograph sidereal time signals alternately through the different points, while at the same time mean time signals were being recorded through an independent circuit. When the French observers arrived, Prof. H. Abraham of the Université de Paris brought with him two galvanometer pen chronographs designed by himself and especially adapted for the recording of such lags, and he very kindly loaned one to the Naval Observatory. It was more convenient in use than the other arrangement and gave practically the same results. There was a small systematic difference of $0^s.004$ between the results obtained by the two methods which was attributed by Prof. Abraham to the superior sensitiveness of his chronograph. For a short period at the beginning the relative lag between the Radio and American chronograph points was $0^s.010$. The point then in use having been shown by records on the much more sensitive photographic galvanometer chronograph of Prof. Abraham to be defective, the chronograph circuit was changed to the other available point of the relay and after adjustment the lag was $0^s.000$ and remained so throughout the work. In general two records of the lag were made each night. The time from the closing of the contact at the observatory to the reception of the signal in the telephone receiver at Radio was measured and was found to be negligible.

At Paris the Riefler clock sends its signals on the even seconds (omitting for identification the 58th second of each minute) and synchronizes a "clock relay" which distributes the signals to the chronographs. The synchronizing circuit apparently operates when the pendulum of the clock relay is at its lowest point and the signal circuit is closed near the end of the swing of the pendulum so that the lag is either approximately $+ 0^s.5$ or $+ 1^s.5$, according to the direction in which the pendulum is swinging when it is synchronized, and as the clock relay omits no signals for identification and the signal nearest the zero of the Riefler is usually called zero the result is that the lag is either approximately $+ 0^s.5$ or $- 0^s.5$. If the control is out of action for a time or if the relay is stopped and started again, it is readily seen that the lag may change from one value to the other.

The probable error of a clock correction from a single star, including the errors of star places, would indicate a probable error of $\pm 0^s.008$ at Washington and $\pm 0^s.010$ at Paris for a clock correction from an average night's work of about twenty stars. The intercomparison of results by the different observers on the same instruments and of the results of the French and American observers on different instruments indicates a probable error of clock correction of $\pm 0^s.013$ for Washington, and $\pm 0^s.015$ for Paris, which is considerably larger. The difference is due perhaps to variable personal equations or imperfect instrumental action.

The clock corrections were plotted, and the curves satisfy the observations for Washington with a probable error of $+ 0^s.012$ and for Paris with a probable error of $\pm 0^s.015$. The use of these curves also furnishes a means of utilizing all the radio observations on whatever nights they were obtained.

As the epoch of the Washington time observations was about 2½ hours after that of the radio observations, and that of the Paris time observations was about 2½ hours before that of the radio observations, the effect of the above differences on the resulting longitudes may be approximated as follows:

I	II	Mean
$+ 0^s.017$	$- 0^s.049$	$- 0^s.016$

At each station the programme for the radio work was essentially the same. At Radio, for example, a Leroy clock controlled the emission apparatus so as to send out three series of 420 signals omitting for identification the multiples of sixty, the intervals between the successive signals being approximately $0^s.99$, and each signal being $0^s.5$ long. The radio observer observed by ear by means of telephone receivers the coincidences of the outgoing signals with the beats of a mean time chronometer, and as the chronometer beat half seconds, he observed a coincidence about once in fifty seconds, or usually seven or eight in a series. He also noted the omitted signals in such a way that the serial numbers of the signals at the coincidences could be determined. With this data it is possible to determine the chronometer time of any desired beat in the series of 420 emitted by the Leroy clock.

The radio signals having been compared with the comparing mean time chronometer, this was in turn compared directly with the standard Riefler sidereal clock of the observatory by the same coincidence methods, securing usually four coincidences for each comparison, and two comparisons each night, one just before and one just after the radio work.

From the comparisons of the signals from the emitting clock with those from the comparing chronometer, it is possible to obtain a chronometer time from each coincidence for any signal in the series selected as a reference signal, and by means of the comparisons of the comparing chronometer with the Riefler clock and the determined corrections to this clock, it is possible to obtain the local sidereal time of this reference signal. In order to eliminate the errors in the assumed rate of gain of the emitting clock on the comparing chronometer due to errors of observation, the signal whose number in the series corresponds to the mean of the numbers of the signals at which coincidences were observed should be taken as the reference signal. As this number is different for the two stations, the signal corresponding to the mean of the two numbers was used as the reference signal, and in this way these errors were rendered negligible though not completely eliminated. Having determined the local sidereal time of the reference signal at Washington and at Paris, the difference of these times is the difference of longitude.

The distance from Paris to Washington being 3,830 miles, the ascertained transmission time corresponds to a velocity of 175,000 ± 16,000 miles per second.

The transmission time from Paris to Bizerte (see *Différence de Longitude entre Paris et Bizerte*, p. 107), was determined to be $0^s.0071$, and as the distance is 963 miles, this corresponds to a velocity of 136,000 miles per second.

The correction for time of transmission as determined above has been applied to all the longitude results. All of the available radio observations for each night, omitting series in which but a single coincidence was observed, have been combined to form a single longitude determination. There were nine nights in the first period and eight nights in the second period when astronomical observations were secured at both stations and when radio observations were made at one or both stations. There were also five additional combinations of nights in the first period, and five in the second period when independent longitude determinations can be obtained by carrying the clock correction at one or both stations for from one to three days by means of the clock rate. In view of the excellent installation and good performance of the clocks at both observatories, this is considered a safe proceeding in the present case. The weight assigned for the longitude of a night is based on the number of series of radio observed, the number of coincidences observed in the series, the number of stars observed, and the number of days the clock corrections have been carried by the rates.

From the data obtained values of the observed longitudes have been deduced for the first and second periods of the work:

$$\text{I} \quad 5^h\ 17^m\ 36^s.016 \quad \pm 0^s.0115$$
$$\text{II} \quad 5\ \ 17\ \ 36\ .811 \quad \pm 0\ .0054$$

By applying the correction $-0^s.056$ to each in order to reduce to the adopted meridians of Washington and Paris, respectively, and taking the mean the following longitude, Washington-Paris, is obtained.

$$5^h\ 17^m\ 36^s.658 \quad \pm 0^s.0059 \quad (A)$$

The probable error assigned is based on the assumption that the difference between I and II is due chiefly to differences of personal equation between the astronomical and radio observers of the two parties and other similar errors and that the effects of those errors are eliminated in the mean. The extent to which this is the case will be shown further on.

If the longitude is based on the seventeen nights on which astronomical observations were made at both stations, the result is

$$5^h\ 17^m\ 36^s.642 \quad \pm 0^s.0065 \quad (B).$$

If the longitude is based on clock corrections derived from the common stars observed the same nights at both stations, thus eliminating the errors of the star places, the number of nights is reduced to fifteen, and the result is

$$5^h\ 17^m\ 36^s.638 \quad \pm 0^s.0061 \quad (C)$$

If the longitude is based on clock corrections derived from the three hour group nearest the time of the radio comparisons at each station, thus reducing the effect of errors in the adopted clock rates, the number of nights is reduced to fourteen and the result is

$$5^h\ 17^m\ 36^s.639 \quad \pm 0^s.0073 \quad (D).$$

If the longitude is based on the seventeen nights as in (B) but using clock corrections from the curve instead of the observed clock corrections for each night, the result is

* Abstracted from a paper in *The Astronomical Journal* communicated by Capt. J. A. Hoogewerff, U. S. Navy, Superintendent U. S. Naval Observatory.

$5^h\ 17^m\ 36^s.652 \pm 0^s.0042$ (*E*).

By the use of the clock corrections derived from the curve, all the radio observations, made on 67 nights, can be utilized.

From the data thus secured the following values of the observed longitude for the first and second periods of the work have been deduced:

I $5^h\ 17^m\ 36^s.614 \pm 0^s.0049$.
II $5\ \ 17\ \ 36\ .818 \pm 0\ .0027$.

By applying the correction $-0^s.056$ to each to reduce to the adopted meridians of Washington and Paris, respectively, and taking the mean, the following longitude, Washington-Paris, is obtained:

$5^h\ 17^m\ 36^s.658 \pm 0^s.0029$ (*F*).

This value is considered the best of the six given above, which, though preliminary, will not differ materially from the definitive values to be published in an appendix to Volume IX, *Publications of the U. S. Naval Observatory*, Second Series.

	I	II
Correction due to diurnal variation in clock rates	$+0^s.017$	$-0^s.040$
Correction due to lag determination for Paris I............	$+0.010$	
Correction due to variation of longitude	$+0.001$	-0.009
Correction due to systematic differences in levels	$+0.026$	-0.030
Correction due to difference of radio observers personal equations	$+0.020$	-0.020
Correction due to difference of astronomical observers personal equations	-0.028	$+0.008$
Total	$+0^s.046$	$-0^s.100$

Previously determined values of the transatlantic longitudes are as follows:

From Eclipses and Occultations	Years	Washington, Old Obs'y—Greenwich	Washington, New Obs'y - Paris
1. Walker.....	–1843	5h 8m 11s.14	5h 17m 35s.70
2 Peirce.....	1851	11 .57	36 13
3 Peirce......	1839	11 .45±0s.8	36 01
4 Peirce......	1856–1861	13 13	37 69
From Moon Culminations			
5. Walker...	1843–1845	10s.01	34s.57
6. Loomis....	1838–1844	9 .3	33 86
7 Gillis ..	1838–1842	10 04	34 .60
8. Walker..	1845	9 60	34 16
9. Newcomb...	1846–1860	11 .6 ±0s.4	36 18
10 Newcomb ..	1862–1863	9 8	34 36
From Chronometers			
11.	–1849	12s 46	37s.02
12. Bond......	1849	11 .14	35 70
13. Walker ..	1849	12 00	36 56
14. Bond	1840	12 20±0s 20	36 76
15. Bond. .	1855	13 43±0 .19	37 99

By Cable	Years	Cambridge Greenwich	Washington New Obs'y - Paris
16. Gould....	1866	4h 44m 30s.801 ±0s 000	5h 17m 36s 56
17. Dean .	1870	31 065 ±0 .056	36 .73
18. Hilgard	1872	31 .018 ±0 041	
		Cambridge—Paris	
18. Hilgard .	1872	4h 53m 51s.951 ±0s 051	36s 09
		Montreal—Greenwich	
19. Greenwich Obs'y — McGill University ...	1892	4h 54m 18s.62 ±0s 024	36s 70

In reducing these longitudes to Washington-Paris, the following adjusted differences of longitude have been used.

20.	Greenwich Paris	0^h	0^m	$20^s.932$
21.	Washington—Cambridge	0	23	41 .107
22.	Montreal—Cambridge	0	9	47 .588
23.	Washington, New Observatory—Old Observatory	0	0	3 .631

The Washington-Paris longitude given in the *American Ephemeris and Nautical Almanac* for 1901 to 1915, $5^h\ 17^m\ 36^s.75$, is correlated with the Paris-Greenwich longitude, $9^m\ 20^s.97$, which has been superseded by the value $9^m\ 20^s.93$, corresponding to a Washington-Paris longitude of $5^h\ 17^m\ 36^s.71$. This value depends on the Washington-Greenwich longitude resulting from the adjustment made by Schott,[1] which is

$5^h\ 8^m\ 15^s.78 \pm 0^s.05$

This longitude depends largely upon the result of the 1892 cable determination of the longitude Montreal-Greenwich. At the time of the adjustment only the preliminary value of this result was available. As the definite value gave a correction of $-0^s.05$ to the preliminary value, it is evident that Schott's value of the longitude Washington-Greenwich is too large.

Assuming the Greenwich-Paris longitude[2] to be

$0^h\ 9^m\ 20^s.932 \pm 0^s.014$

the Washington-Greenwich longitude resulting from the present determination is

$5^h\ 8^m\ 15^s.726 \pm 0^s.014$.

1 15 *U. S. Coast Survey Report*, 1867, pp. 59, 60

16, 17, 18. *U. S. Coast and Geodetic Survey Report*, 1897, pp. 247, 248, see also p. 241 and 1872, p. 234 and 1884, p. 420.

19 Royal Observatory Greenwich. *Determination of Longitude*, 1888-1902, p. 124

20 *Astronomische Nachrichten*, No. 3993, p. 157

21, 22, 23 *U. S. Coast and Geodetic Survey Report*, 1897, pp. 253, 260.

[1] *U. S. Coast and Geodetic Survey Report*, 1897, pp. 254, 259, 260

[2] *Astronomische Nachrichten*, No. 3993, p. 157.

How Narcotics Affect Plants

The term narcotics is given in general to those substances which exercise a powerful effect on the central nervous system of men and animals. This effect consists mainly of a period of excitation followed by a period of depression or reduced sensibility, which may end in stupor or even in death. However, the total effect is a complex of phenomena, which vary according to the nature, the dose, and the duration of the narcotic.

There is no physical or chemical property which all narcotics certainly possess, but the majority of them are marked by volatility and an intense odor, nearly all are soluble in lipoids or fatty substances, and it seems probable that all are able to penetrate living plasma.

While plants cannot be said to have a central nervous system, the studies of plant physiologists in recent years have increasingly shown a marked analogy between their vital functions and those of animals. Among the most striking of these analogies are the way in which they react to certain narcotics. Many investigators have of late been experimenting along this line, and the results of their research are lucidly set forth in an article by Dr. Arthur Heilbronn in *Die Naturwissenschaften*, which we here summarize.

It is very difficult to distinguish between narcotics and poisons, for in large doses or too great duration the former are always fatal. But susceptibility to them varies greatly in species and individuals, and the same thing has been found true of plants. This susceptibility, too, can be lessened by gradually accustoming the individual to larger and larger doses, a fact of which Dumas made romantic use in one of his most thrilling novels, and which De Quincey verified in real life, as do all "drug fiends." Even so can plants be inured to the narcotics.

The best known narcotics are alcohol, ether, and chloroform, but there are many others, among them benzol, xylol, and benzin. Narcotic gases include the compounds of hydrogen and oxygen in illuminating gas, carbon dioxide, and the fumes of ammonia and Prussic acid. They also include such solid bodies as chloral hydrate, certain compounds of calcium, and many alkaloids. It is also a form of narcosis termed by Dr. Heilbronn *autonarcosis*, which occurs in plants surrounded by an atmosphere having insufficient oxygen, a condition which may occur when the temperature is either too high or too low. "Perhaps," he says, "the above-mentioned carbon-dioxide narcosis belongs in this group. We must believe that under these abnormal conditions of metabolism narcotic substances are formed in the plant. . . ."

Zaleski proved that respiration in onions was stimulated by a narcosis of six hours, but depressed when the duration was longer. A practical application of this stimulation of respiration is given in the Johannsen process of forcing by ether. In this the ether produces not only acceleration of respiration, but, indirectly, of growth. A narcosis of from 12 to 48 shortens the rest-period in various plants from six to eight weeks.

"In these cases the narcotic develops its effect only in the preliminary and after-periods of rest and not in the middle period. In both periods a struggle takes place between the stimulation and the inhibition of growth. The ether is favorable to the first process, hence the result attained. This phenomenon has an analogue in the animal kingdom: the rest-period is shortened by ether both in the eggs of insects and the pupæ of butterflies, according to Fischer. A success similar to that in the forcing of twigs in their winter rest-time is attained in the case of grains of barley, which have just matured and are in the early period of the rest-time. They may be made to germinate while still attached to the parent plant, a case of experimentally obtained vivipary."

Another remarkable instance of the modification of vital functions by narcotics is the checking of fermentation, according to Claude Bernard. Dr. Heilbronn, however, considers this so astounding that it is in need of proof by control experiments. It is certain, though, that assimilation may be temporarily checked by narcotics oth in the Algae *Spirogyra* and in higher plant forms. "This inhibition is probably only a special case of the quite general anticatalysatoric effect of many narcotics, i. e., their ability to retard chemical processes which are set in operation by a catalysator. This may have its fundamental cause in alterations of surface-tension relations in narcotic atmospheres."

The effects of narcotics upon transpiration are quite curious. Mildly narcotized leaves transpire more strongly in light, but less strongly in the dark, than the normal. Jamelle gives the following explanation for this: assimilation is interrupted by the assimilation, and consequently the entire energy of the rays of light absorbed by the chlorophyl is utilized in transpiration. Dr. Heilbronn considers this debatable and discusses it at some length.

Another effect of narcotization is interference with the process of assimilation. The conduction of products of assimilation in germinating seeds is cut off, since they cannot pass through narcotized leaf-stems or pieces of the stalk. This is considered additional proof that the co-operation of the living plasma is indispensable for the conduction of assimilated substances. But hydrolytic processes, such as the dissolving of starch, continue. The natural consequence of this is an accumulation of osmotically active substances, such as sugar, asparagin, etc. An increase of osmotic pressure is necessarily associated with this, and this leads in its turn to rankness of growth. In this connection it is of especial interest to note that there is a displacement in the growth. The longitudinal growth is checked, while the growth in thickness is advanced. But this holds good only for mild doses. A stronger narcosis interrupts all growth.

Dr. Heilbronn also dwells at some length on the manifold modifications of the nuclei of narcotized plant organs and the influence of narcotics on the plasma-current. Without entering into the technicalities of the discussion we may quote the following passage: "It is evident that the viscosity of the living substance is increased by large narcotic doses, and we have known also since the earliest studies of narcosis in plants that a typical criterion for narcotic action is a decrease in intensity of reaction to exterior stimuli. It is an obvious matter to bring those two facts into casual connection and to regard alterations in the physical structure of the plasma as the cause of the altered physiologic function."

The decrease of sensitiveness was the first thing which led to the discovery that there was such a thing as narcosis in plants. Marcet proved as far back as 1848 that the mimosa ceased to be sensitive under the influence of chloroform, and the next year Clemens showed that ether had the same effect. Many other observers noted the influence of narcotics on various plants in inhibiting curving movements.

Dr. Heilbronn recounts of special interest Czapek's observation that the geotropic curving capacity of a plant organ is suppressed by a considerably lower concentration of a narcotic than its geotropic sensibility; consequently, therefore, the curving capacity is inhibited by a mild narcosis while the perception capacity is retained at the same time. Hence, it is possible to induce a geotropic stimulus in narcotized legumens as whose result after the sleep-state has passed away there follows a geotropic curving, though the stimulus is no longer present. We pass over the theoretic explanation of this. He continues: "We have just mentioned a case in which perceptivity is retained while motility is inhibited; the following example shows that the reverse can be the case, at least for light stimulus. *Bacterium termo* retains its motility completely in mildly narcotic liquids; but while it constantly hastens toward the source of light it has entirely lost its phototropic sensibility."

An interesting point is that in organisms which react with the same movements to different stimuli it is possible to differentiate these stimulus-movements by the aid of narcotics. Thus, the mimosa responds to a touch just as it does to the withdrawal of light; but, according to Bricker, there is a certain dose of ether which just suffices to make the plant insensitive to touch while retaining its "sleep-sensibility."

"The tropisms likewise exhibit a various sensibility to narcotic influences. Geotropism is especially easy to check, even by doses which cause an increase of heliotropic sensibility. The autotropisms, too, are considerably more difficult to check by narcotics than geotropism. . . ."

Dr. Heilbronn concludes with the observation that since in the lowest forms of life, in the higher plant-forms, and in the most highly organized organisms that exist sensibility to external stimuli is decreased by the same narcotic agents, this constitutes an argument in favor of the view that there is an essential similarity in the living substance of all organisms, and we may conclude therefrom that the primitive signs of sensibility to external stimuli which we find at the bottom of the world of organisms bear an intimate relationship to the complicated nervous reactions of modern man.

The Roosevelt-Rondon Scientific Expedition—II*

Its Movements in South America and Some of Its Zoological Achievements

By L. E. Miller, Mammalogist of the Expedition

Concluded from Scientific American Supplement No. 2050, Page 249, April 17, 1915

Caymons were particularly plentiful in the Upper Paraguay. Scores of the evil-looking creatures lay on the sand banks, with wide-open mouths and staring glassy eyes. A fringe of trees flanked the water through which we could see the boundless wastes of *pantanals* beyond; troops of black howling monkeys ambled leisurely away as the boat drew near, and a species of curious gray-throated parrakeet was building tremendous nests in the branches; occasionally in the same tree there were two or three nests each several feet in diameter, which the birds were entering and leaving like bees at a hive.

Sao Luis de Caceres was reached January 15th, and at noon the next day the "Nyoac" weighed anchor again and pointed her nose up-stream. That night we reached a small station known as Porto Campo, and as the river was too shallow to permit the steamer to ascend further, our effects were taken ashore and tents erected for a temporary camp. A few days' hunt at this point resulted in an addition to the collection of tapirs and white lipped peccaries shot by Colonel Roosevelt, besides a goodly amount of smaller material. The preservation of the large specimens was somewhat of a problem as the time at our disposal was wholly inadequate, and there was practically no available native help. All the skinning and preparation was done by Kermit Roosevelt and the writer, although at times valuable assistance was rendered by Mr. Sigg.

January 13th found the expedition aboard a launch (one boatload had preceded us) struggling against the swift current of the Sepotuba. A heavy houseboat full of provisions and luggage was towed alongside and we made slow progress. There is an end to all things of earth however, and the end of our river journey came on January 16th. We had reached Tapirapoan, the furthest outpost on the frontier, and immediately preparations were begun for our long dash across the *chapadao* of Matto Grosso

Tapirapoan presented a scene of festive gaiety upon the arrival of the expedition at that point. The large, open square around which clustered the low mud-walled huts was decorated with lines of pennants, while the American and Brazilian flags fluttered from tall poles. Flag raising and lowering was always an impressive ceremony; everybody lined up and stood at attention while the banners were solemnly raised or lowered, as the case might be, to the strains of martial music.

A large number of horses, mules and oxen had been gathered from the surrounding country; the army of natives or *camaradas* who were to have charge of them and the impediments, had assembled, and the wardrooms were filled with cases and bags of provisions and equipment. To organize properly a cavalcade of such large proportions required some little time, but within six days of our arrival order had been restored out of chaos and the first detachment of the expedition started. This included all of the Americans, and several Brazilians to whose number Lieutenants João Lyra and Joaquin de Mello Filho had been added. Captain Amilcar was to follow the next day with the remainder of the caravan. This division of the party was absolutely necessary as, on account of the great quantity of men and animals required, the expedition would have been unwieldly if it had attempted to move in one body.

The first day's ride was a short one. Early in the morning the men started to load the pack animals, many of which were apparently fresh from the rancho and had never been broken to work of any kind, so that there was a good deal of confusion at first. But gradually the men became more adept at their work, the mules and oxen quieted down and little squads left the corrals, wound up the trail and disappeared in a cloud of dust. We did not follow until noon. Our mounts were good strong animals; we had both horses and mules, and comfortable saddles were also provided by the Brazilian commission. A four hours' canter through brush and forest-covered country brought us to the Sepotuba again, quite some distance above Tapirapoan, and we crossed the stream on a pontoon ferry made by laying a platform of boards across three dugout canoes. There were a number of new palm-leaf houses on the river bank, so these were used for the night's camp instead of erecting the tents.

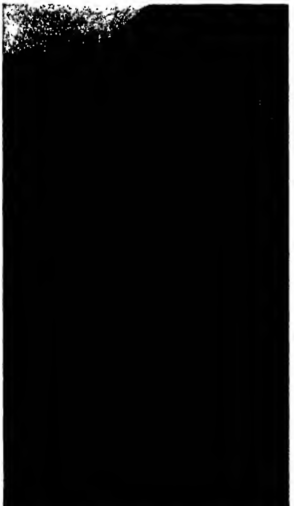
Next day we were in the saddle by nine, riding through tall virgin forest with occasional stretches of sandy soil in which only low bushes grew. It was evident as we penetrated farther into the interior that the forest zone was fast disappearing, to be replaced by the vast *chapadao*[13]. The heat was intense; there was no rain, and troublesome insects were lacking. At three o'clock in the afternoon we entered an old clearing. Formerly rice, plantains, mandioca[14] and corn had been cultivated here, but now the place was deserted and overgrown with weeds. Kilometer 52, as the spot was called, had been an important camp of the telegraph commission while work was being prosecuted in that region, but had long since been abandoned.

On January 23d, a 32-kilometer ride took us to the site of an old Indian village, known as Aldeia Queimada. We were adhering closely to the telegraph line, following the wide swathe that had been cleared to protect the wires from falling trees and branches, except when a short detour was desirable to find a better crossing for some small stream. The country was of a gently undulating character, covered with wiry grass and a very sparse growth of stunted, gnarled trees. This vegetation is typical of the *chapadao*. With the exception of a few small deer and a number of birds (woodhewers and jays) there were no evidences of animal life. A clear, cold spring rippled over a pebbly bottom near our night's camp. It was the last stream we should see which discharged its water (via the Sepotuba) into the Rio de la Plata system.

* From the American Museum *Journal*.

[13] *Chapadao*: high, nearly level upland covered with scanty scrubby forest.

[14] Mandioca: also called "manioc," the cassava plant.



Nhambiquara women and children with baskets of vegetables from the fields.

Parecis Indians playing head ball. They show wonderful dexterity in striking with their heads the hollow rubber ball, a foot in diameter.

Parecis Indians returning from the field. They raise large crops of mandioca, corn, sweet potatoes, make clothing, hammocks and various ornamental articles.

Colonel Rondon had employed a number of motor trucks in constructing the telegraph line through this section of the country, several of which were still in serviceable condition. It was therefore decided that a part of the luggage should be sent ahead on the cars as far as the trail permitted, and as there would be a wait of several days while the remainder of the expedition caught up, Mr. Cherrie and I went along to devote to collecting the time thus gained. Doctor Zahm and Mr. Sigg accompanied us. We started two days beyond Aldeia Queimada, from a point called Rio Mandioca. There were three motor trucks, great well-built machines of German make, laden to their fullest capacity with the heaviest and most cumbersome pieces of the baggage. It was a strange sight to see them racing across the uninhabited *chapadao*, at a speed of thirty miles an hour, and frequently through blinding rain and deep mud. One of the cars had a full-blooded Indian mechanician who seemed to be fully initiated into the mysteries of handling an automobile, from gathering up branches and stones with which to fill up the roadway when the broad wheels mired deep in the loose sand, to repairing the engines on the rare occasions when such a procedure was necessary.

We reached the Rio Sacre, beyond which point the trucks could not proceed, on the evening of the 28th. The river is here broken by a fall 150 feet high. As elsewhere in South America, we were constantly reminded of the appalling lack of animal life. During the entire three days required to reach the Rio Sacre we saw only a few rheas, a soriema[15] or two, and a number of deer.

On the morning of the 29th, we crossed the Sacre on a pontoon ferry, and using a number of animals which had been held in readiness there, rode the two leagues to Utiarity, a village of the Parecís Indians; the Rio Papagaio, a clear, swift stream flows past the settlement, and half a mile away dashes over the brink of a precipice 250 feet high.

The Parecís are a small tribe of semi-civilized Indians who live in substantial huts and cultivate large fields of mandioca, corn and sweet potatoes. Some of them wore clothes while many wore only a breech-cloth of their own weaving. They also make hammocks and various articles for ornamental purposes. The youths of the tribe engaged in a curious game of head-ball, using for the purpose a hollow rubber sphere a foot in diameter, which they themselves manufacture. They chose sides and batted the ball back and forth across a line, with their heads. The hands were not used, and they displayed remarkable dexterity and tireless energy at this form of amusement. One evening just before sundown, practically all of the men joined in a sacred dance. For this occasion they were clothed in gaudy red head-bands from which protruded the brilliant feathers of the great blue and yellow macaw; bead neck chains and belts, and anklets made of bunches of curious dry seeds which kept up a continuous rattling sound as the dancers stamped in rhythm with the low, wailing music of reed flutes. They stopped frequently to drink *chicha*,[16] and at intervals they sang the names of their dead warriors and mighty hunters, and called upon them for guidance and assistance.

Utiarity proved to be a profitable collecting place. Many small rodents and a few larger mammals, including a soft-shelled armadillo collected by Colonel Roosevelt, were taken, besides a number of birds. We spent five days in the village (Colonel Roosevelt arrived three days after we did) at the end of which time Doctor Zahm accompanied by Mr. Sigg left the party and started back home. A short time later Mr. Fiala began his homeward trip down the Papagaio and Tapajos.

Utiarity had been the first telegraph station in operation along the new line; the second was on the banks of the Rio Juruena, approximately 100 kilometers away, and it required five days to reach this point. We had been compelled to reduce the amount of our baggage very materially shortly after leaving the Parecís village, as many of the cargo animals had given out on the trail, and the others were weakening perceptibly. Most of the tents were abandoned, and all superfluous clothing was left behind. The equipment for collecting and preserving specimens, unfortunately, had to be reduced also, on account of its weight, so that we retained only a few hundred cartridges and about a dozen traps with which to prosecute the natural history work. This reduction of the impedimenta was unavoidable and affected every member of the party either directly or indirectly. It was one of the several instances where individual interests had to be sacrificed for the good of the whole expedition.

[15]Seriema: a large, long-legged crested bird, probably related to the cranes.

[16]Chicha: a fermented drink made from maize or cane sugar.

Type of Indian assistant, or camaradas, employed by the expedition.

At Juruena we made the acquaintance of a primitive tribe of Indians who probably represent the lowest type of civilization to be found anywhere on the South American continent. They are known as the Nhambiquara. As we drew up on the river bank they gathered about and stared at the party curiously, but betrayed no hostile feelings. Colonel Rondon had but recently succeeded in establishing amicable relations with them. On his first visit to the country, numbers of his men had been slain by their poisoned arrows, and they had resented his every step into their stronghold; but having been persistently treated with kindness, they have learned to look upon him as a friend, and some of them even appeared to be heartily glad to see him.

In stature the Nhambiquara is short, but well built, and of a very dark brown color. Clothes are absolutely unknown to them, and practically the only ornaments in their possession are strings of beads which they had received from Colonel Rondon. Some of the men have the nose and upper lip pierced and wear pieces of slender bamboo in these perforations. Their huts or *malocas* are rude structures of grass or leaves, and they cultivate small areas of mandioca, but wild fruits, game and wild honey form the principal articles of their diet. Bows six feet tall and made of palm wood, and long bamboo arrows are used both in hunting and in warfare. Frequently hunting parties go on long tramps through the jungle, subsisting entirely on the fruits of their prowess. At night a rude lean-to is built of branches, the game is roasted in a roaring fire and eaten, and then they stretch themselves on the bare ground to sleep.

We remained a day at Juruena to rest and to develop films. The pictures taken by the various members of the party form one of the important records of the expedition, and great care has to be exercised in developing all exposed films promptly or they would be spoiled because of the hot, damp climate.

The country beyond the Juruena is somewhat rolling, but there is no appreciable change in the vegetation. We rode 20 kilometers the first day, camping on the banks of the Rio do Formiga (February 10th). Next day we travelled but 12 kilometers, reaching the Juruena, a shallow though rapid stream 100 feet wide; the crossing was slow and laborious as there was only a very small *balsa* or ferry. Camp was pitched a league beyond, on the banks of a small stream. Near by were several deserted thatched huts, and the comparatively new graves where three Brazilians, one an army officer, had been buried. They had been slain by the Nhambiquara and buried in an upright position with the head and shoulders protruding above the ground. The following night, on the Rio Primavera we saw two other graves. The two men who had been interred here were slain while asleep in their hammocks. This was the most dangerous part of the whole Nhambiquara country.

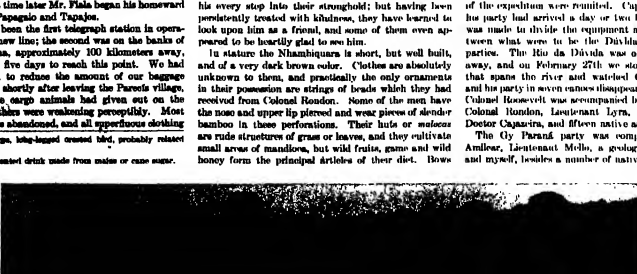
Campos Novos was reached February 16th. Formerly the third telegraph station was located here, but it now stands on the Rio Nhambiquara, a league away. We were on the border of the great Cerro do Norte, a vast tract of country comprised of high, broken plateaus or mesas covered with luxuriant grass. Many small streams flowed through deep gorges, and near some of the water courses, tall dense forest grew. The soil is fertile and would produce crops of corn and rice, cattle in great numbers could be reared on the extensive mesas, and the climate is cool and healthful. There are few portions of South America so well suited for colonization by Europeans, but on account of the remote location and the lack of means of communication, it will be several decades before this vast and fruitful region will become inhabited.

After leaving the Cerro do Norte, February 23d, we again entered *chapadao* country; but the wiry grass and stunted trees were gradually being superseded by forest. Occasionally all other vegetation gave way to large areas of wild pineapples. There were many square miles of them, bearing fruit which was small but of delicious flavor.

We added few specimens to the collections after leaving Utiarity. Animal life was not abundant, and the rapid pace at which the expedition was compelled to move left no time for collecting. At José Bonifacio, which was reached February 24d, an interesting rodent, somewhat resembling a gopher, was taken. In order to secure the single example it required a half day's time and assistance of five Nhambiquara. A reward of bunches of coral beads had been offered the Indians if the animal was secured, so they immediately began work with sharpened sticks and with their hands. By noon they had excavated 10 cubic yards of earth and won the prize. The expedition had gone on ahead but was overtaken in the evening.

At a camp named Siete de Setembre the two divisions of the expedition were reunited. Captain Amilcar and his party had arrived a day or two before, and a halt was made to divide the equipment and provisions between what were to be the Dúvida and Gy Paraná parties. The Rio da Dúvida was only 10 kilometers away, and on February 27th we stood on the bridge that spans the river and watched Colonel Roosevelt and his party in seven canoes disappear down the stream. Colonel Roosevelt was accompanied by his son Kermit, Colonel Rondon, Lieutenant Lyra, Mr. Cherrie and Doctor Cajazeira, and fifteen native assistants.

The Gy Paraná party was composed of Captain Amilcar, Lieutenant Mello, a geologist, a taxidermist and myself, besides a number of natives. We traveled



Nhambiquara women and children.

These people probably represent the lowest type of civilization on the South American continent.

three days longer to reach the Commemoracao. The spot was called Barao de Melgaco and marked practically the end of the telegraph line. The trip from Tapirapoan to the Commemoracao had required exactly 40 days, the distance is approximately 548 miles. Many of the pack animals were in such poor condition that they had to be shot. It is impossible to say how many had been lost on the way, but the number was very large.

Barao de Melgaco seemed to be the headquarters of annoying insects and disease. Most of the handful of men at work on the telegraph lines were ill with fever and beriberi and there had been twelve deaths just before our arrival.

We had expected to find canoes awaiting us, but as there were none, the men cut down a tree of ample size and began making one. This work we estimated would require a month, but after a wait of two weeks a large canoe arrived from down the river.

The time at Barao de Melgaco was profitably if not pleasantly spent. All about the little clearing rose the stately Amazonian forest, providing admirable collecting grounds. Many birds and mammals were taken, all new to the collection. The latter included an undescribable spider monkey and a saki[*] of a new genus.

We started down the Commemoracao March 13th and traveling rapidly with the current reached the Pimiento Bueno 80 kilometers below, that night. The junction of the two rivers forms the Gy Paraná.

The Gy Paraná at its very beginning is a mighty river a thousand yards wide, and day by day as we raced with its swirling torrent we watched its rapid growth until near the mouth it reached a breadth of at least two miles. The country on both banks is heavily forested and along the upper course is inhabited by a tribe of Indians which had been absolutely unknown. We were the first white men to see them and they had never seen white men before. In appearance they differed greatly from their neighbors the Nhambiquara. We met seven all men and finally induced them to accept gifts of beads and knives in return for which they gave us wonderfully decorated arrows six feet tall.

The Gy Paraná abounds in formidable rapids like many South American rivers, and we had numerous overland portages, the longest being about three miles, around the falls of São Vicente. Insects are abundant, and the whole region is a vast breeding ground for malaria. A number of rubber camps are situated on the lower river, the forests being rich in hevea. We reached Manaos April 10th, having stopped at Calama, a station on the Madeira, for a short period of collecting.

As the Duvida party had not arrived, I almost immediately left for the Rio Solimoes where several weeks were spent to advantage adding to the collections. Among the large number of specimens collected were agoutis, woolly monkeys, squirrel monkeys, sloths, many small rodents and squirrels all new to us, and the complete material for a group of hoatzins or lizard-birds was also collected. The collections now numbered about 1 500 birds and about 415 mammals practically all of species unknown to us and some of which are no doubt new to science.

Colonel Roosevelt's party reached Manaos the last day of April, but the story of their experiences on the unexplored river is too well known to warrant review.

[*] Saki, a South American monkey with a bushy tail and a ruff of long hair around the face.

Wireless Transmission of Energy—II*

An Explanation of its General Nature and Relationship to Transmission by Wire

By Elihu Thomson

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2050, Page 253, April 17, 1915

Let us suppose that the charge is positive at the top and necessarily the surface below and surrounding the mast will be negative. Electrostatic lines will extend from the mast and particularly from the expansion at the top down to the earth's surface in all directions around the antenna as in the figure. The medium around the antenna will be stressed electrostatically. This would be all provided the charges were stationary, but the system we are considering is dynamic. The plus charge is replaced by a minus charge at the top and a current of a high frequency runs up and down the antenna, but so also does this current extend into the sea

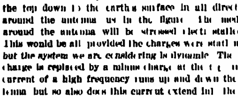


Fig 21A

radially from the foot of the antenna, replacing the negatively charged area by a positively charged zone as it were, while the top of the antenna is now negative where it was formerly positive (Fig 21a, one side only shown, and Fig 21b in plan).

As this action goes on, however, the zone of charged surface widens and ether waves are, so to speak, detached from the antenna, and electrostatic lines join now through the air or ether above the successive zones which surround the antenna as great circles or flat rings of the sea surface. A plus area is followed by a minus, a minus by a plus, etc., and to indicate the effect in the space above, we draw lines which follow these areas, extending up into the ether above the surface but moving away from the antenna with the velocity of light. The moving charges in the sea surface represent radial currents which are in opposite phase at different portions of the sea surface and spreading at 186 000 miles per second, and these currents necessarily generate magnetism or lines of magnetic force in the medium directly above them. These lines extend around in zones with diminishing intensity upward from the sea surface as the distance from the surface increases. Even within the water itself a similar action, but more restricted, takes place. The charges in the water are connected by electrostatic stress lines and the compensating magnetic field follows the current, but this under water effect does not concern us, as what we work with is the energy conveyed in the shape above the sea, the other not being so easily recoverable.

The system as thus far constituted is merely an arrangement for delivering energy in high frequency waves to the widespread medium around the antenna. There is no selective action whereby it is focused anywhere. It is as a voice crying in the wilderness. It can be picked up or recognized in any direction by any one who is within range. If now we are to receive signals such as are made by interrupting or disturbing at intervals this system of radiation of energy, as in ordinary telegraphy, we must set up somewhere a receiving apparatus which will enable us to pick up whatever small fraction of the energy reaches it, and if possible a sufficient fraction of such energy for the recognition of the signals. If the signal can be recognized, no matter how small the fraction of the energy sent out is which we collect at the receiving station—the system succeeds. There is no question of efficient transmission as there is in the ordinary power transmission systems. The latter are for the transmission of energy with as little loss as possible, the former for the transmission of signals only.

In the antenna transmission just considered it is assumed that the surface of the earth is, generally speaking, a good electric conductor. The surface of the sea is sufficiently good. Dry land surface, however, is not a good conducting sheet, and even though moist it is generally so irregularly conducting that obliteration of the waves and loss or absorption of the energy must necessarily occur. Obstacles such as dry rock ranges may absolutely prevent the waves from passing over them. It must be borne in mind that these waves have no inertia as such and that the energy must be guided to its destination by a conducting sheet. This calls to mind the efforts that were made to connect Lynn and Schenectady by a wireless system, but without success. Occasionally signals were received, but in general they were too indistinct to be recognized. It is more than probable that the dry rock ranges of the Berkshires in western Massachusetts were sufficient of an obstacle to prevent the energy of the waves getting across them.

It is also to be questioned whether there may not be another action which interferes with and disturbs the integrity of the waves. It is conceivable that waves may follow a water surface even around a cape, and that a portion of the energy may take a short cut across the land of the cape. If this be so, the longer course would be around the cape, the shorter course across the land. The wave-lengths would remain the same, and an out-of-phase relation or interference phenomenon would take place to a greater or less extent. It is manifestly necessary that the energy, by whatever course it follows, shall reach the receiving apparatus in phase.

Let us now consider for a moment the conditions at great distances over the earth's surface. At moderate distances from the transmitting antenna the surface may be considered as flat. The conducting sheet guiding the energy is flat or plane, but at great distances the curvature of the earth's surface becomes an important factor. For a time there was a great deal of discussion as to the reason why the energy in the wireless transmission seemed actually to follow the curvature of the earth instead of going straight away as in the case of Hertzian or heat and light waves. If the waves had been generated by a large Hertzian oscillator it would not be possible for them to so follow the earth's curvature, but inasmuch as they are in wireless work produced and, as it were, positioned upon a conducting sheet (the sea surface), then it follows that the energy must be guided by that conducting sheet or surface regardless of its extent or its curvature. I have never been able to understand why so much discussion has been needed to clear up this point. Wireless waves have no inertia—they follow the course of the charges which produce the stress and of the magnetic field due to these charges in motion. These charges in motion are the currents in the conducting sheet, which may or may not be curved. In the curved surface of the ocean the zones of charge continually expanding, plus and minus respectively, are still connected by the electrostatic lines above them and the moving charges still generate the same magnetic field as they traverse radially or outward in the curved instead of the plane sheet (Fig 22)

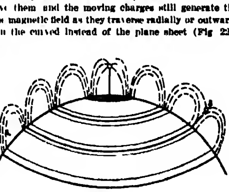


Fig 22

and this curved conductor still guides the energy, just as the wire does in ordinary transmission. It would seem, if this is the correct view, that at a distance comparable with that of a quadrant of the earth's circumference the form of the wave would be such as to cause the stress lines to lean backward with respect to the surface, tending to keep their original relation to the transmitting antenna as they were detached therefrom (Fig 22, at *L*). This assumes that the velocity of transmission is the same as that of the speed of light, both for the currents in the sea and for the stresses above it.

Marconi's success as a wireless pioneer depended largely upon the choice of a sufficiently sensitive receiver. Two elements are necessary in the receiver. First, a conducting structure which gathers up the energy from the medium, the ether, above the earth's surface. The other element is a sufficiently delicate means for detecting the slightest changes of electrical condition, not only actuated by what little energy is received, but so modifying it that it can operate a signal which can be seen or heard. Usually the receiving ap-

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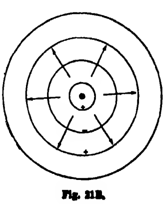
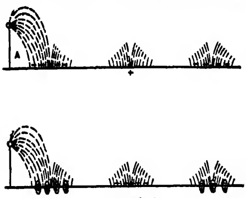


Fig. 21B

tenna is a vertical conducting mast or cage, like the sending antenna. In fact, the functions of sending and receiving are interchangeably used on the same structure; the same antenna may be at one time used for transmitting and at another time for receiving.

The receiving antenna (Fig. 22) serves to relieve the electrostatic stress in its vicinity, much as a lightning rod may act to relieve cloud to earth stresses. If its direction could be made to follow or be parallel to the actual course of the transmitted lines in the space near it, it would be most effective, and if, further, it could extend sidewise over a considerable extent of the wave front, it would gather up more energy. These conditions, however, can at best be only approximately met. If the receiving antenna were of such a character as to have no oscillation rate of its own (a damped circuit) it would receive energy in a small amount from the transmitting antenna independent of the frequency, but as this would in most cases be far from sufficient, it is desirable to accumulate energy in the receiver from a train of waves at a definite rate. To do this the principle of syntony or tuning is brought in. Everyone is familiar with the two tuning forks, where one is sounded and the other is placed at a distance away. If the two forks are not in harmony, no effect of the one fork on the other follows, but if they are accurately tuned in unison, the sound of one fork at a considerable distance from the other starts the second in vibration and produces an audible sound from it. The second fork is, in fact, a structure particularly well adapted to gather up the energy of the sound waves which reach it, receiving from each wave a small portion of energy and accumulating such energy until the fork itself is brought into palpable vibration. By applying this principle in wireless telegraphy, that is, by causing the rate of vibration or frequency of the electrical waves to be the same in the transmission and in the receiving antennæ systems, constructing both to possess a normal rate as if they were to be electrical tuning forks of the same pitch, the amplitude of the received impulses is so greatly increased that signal strength is reached where otherwise failure would have resulted. The one thing which has characterized the more recent advances in wireless telegraphy has been the accuracy of tuning and the removal of disturbing influences which would interfere with the tuning.



Figs. 23 and 24.

Formerly the transmitting circuit was excited by means which tended to disturb the actual normal rate. If excited inductively, the inducing or primary circuit had a rate of its own, which was apt to interfere with that of the vibrating antenna system. However, what is known as loose coupling (Fig. 20), instead of close coupling (Fig. 19), to the primary or exciting circuit causes such confusion of rates to be nearly negligible if, particularly in the exciting circuit, the current is well damped, as it is termed, or confined to a single brief impulse as far as possible. In such case the antenna circuit, in transmitting, acts as if it were a bell struck with a sudden quick blow, and it vibrates at its own rate without disturbance or interference. At the receiving end (and there may be, of course, many receivers in the space around the transmitting antenna), the "listening-in" process consists in adjusting the rate of vibration of the receiving circuit by variable condensers or inductances, so that the maximum loudness of the received signals is attained. The two systems, transmitting and receiving, are then in tune.

Accuracy of tuning is evidently very important if stations are to be simultaneously transmitting when near together, as only in that way can one station send out energy without interfering with the other; the particular receiver for which the signals are intended being tuned for the particular antenna sending these signals. In spite of the accuracy of tuning, however, high-power stations may, in fact, cause high frequency waves of high potential in all surrounding wire or metal structures if near enough. Burn outs, or even fires, may occur from this cause. Hence, it is desirable that high-power sending stations should be well removed from centers of population where there are electric circuits and electrical apparatus likely to be interfered with or injured.

It may be here pointed out that the limit of potential which is available in wireless transmission is the same as that of long distance transmission by wire and for the same cause. Naturally, if the potential on the sending antenna can be raised, the amount of energy which can be put into the wave impulses will be increased, but there comes a time when an increase of potential on the wires of the antenna gives rise to a corona loss, much as the increase of potential in wire transmission produces a corona loss. The conductors of the system, in such a case, are surrounded by a blue discharge which is even visible at night and which frequently can be heard. When this condition is reached every further increase of potential simply increases the corona loss without adding correspondingly to the energy transmission. Just as in wire transmission it can be avoided by increasing the diameter of the conductors, so in wireless work it could be avoided by constructing the antenna system of hollow tubes with smooth exteriors, and the imagination may be permitted to depict a sending tower of polished metal surmounted by a sphere of similar material and worked at millions of volts. No limit can be set to the amount of energy which might thus be radiated, and no limit as yet can be set to the distance around the earth to which signals might be sent by such means.

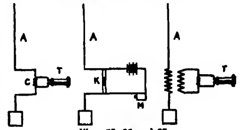
One curious fact which has been developed in the work of wireless signaling is that daylight, especially sunlight, is very detrimental to transmission as compared with the night. That is to say, if the wireless waves are to traverse the sea surface in sunshine, the chance of receiving them in sufficient force to produce signals at great distances is far less than when they are sent at night. It is probable that this difference is not due to any single cause—it may be the effect of a combination of causes. It is a notable fact, too, that this difference between the effectiveness of daylight transmission and night transmission is accentuated at the higher frequencies.

Though the cause is still somewhat obscure, we may venture a suggestion or hypothesis which may have a bearing on the case. Referring to Fig. 23, we have tried to show the condition. The electrostatic field at the water surface at the same instant is, as in Fig. 21, produced in zones around the antenna *A*, spreading with approximately the speed of light. It is well known that under the action of the violet and ultra-violet rays of light any surface having a negative charge will leak its charge and ionize the air near it. This may occur in sunlight over such areas as are marked minus in the figures, and the several minus signs would mark or indicate air ionized and negatively electrified over the negatively charged zones. No action would be expected over the positive areas or zones. But the zones are not stationary; they are widening very rapidly, so that a positive zone or zones takes the place of negative so far as any location is concerned. This may be expressed by saying that the water surface which at one instant was negative and gave out negative ions under the influence of light would, in an exceedingly small fraction of a second and before those ions could get away from electric contact with such surface, become positive and the free ions would now return and neutralize a portion of the positive charge. Thus the negative zones or wave elements would lose part of their charge to ionize air, and the positive waves would be weakened by such negative leak neutralizing them in part. This action, however feeble at each wave, would be continuous over hundreds if not thousands of miles, and continuously damp out the widening system of waves. The effect would be less marked with low-frequency waves, as there would be a proportionately less number of opportunities for this neutralization per second. Besides, with the lower frequency there is more time for the separation of the negative ions to such distance from the water surface that they do not combine with the positive charges, being, as it were, better insulated from them or diffused in the air stratum.

In Fig. 24 an attempt is made to picture this action of attenuation in the presence of light. The negative charges in the air layer, as in Fig. 23, have no positive charges under them, the encircling lines about the + and — signs indicating combination and neutralization.

When the wireless waves reach the receiving antenna, owing to attenuation from spreading or loss as above, they are very feeble. The daylight effect, as pointed out by Fessenden, is much less with the lower frequencies, such as 100,000 per second as compared with 600,000 or 800,000 waves. Consequently there is not the same great difference in strength of signals between night and day work with such lower frequencies. Moreover, frequencies of 100,000 or even 200,000 are capable of being generated directly by high speed high-frequency dynamos with the added advantage that the waves sent out are maintained at their full amplitude and are not, as with waves produced by spark discharges, subject to damping or decay from maximum to zero after a few oscillations.

Whatever the nature of the waves sent out, there is in all cases the need of an exceedingly sensitive apparatus for converting the slight electric effects upon the receiving antenna into signals. The original apparatus of Marconi included the Branly coherer, used by Lodge in Hertzian wave transmission as a detector. It is indicated in Fig. 26 at *K*, with its battery and sounder magnet *M*. The receiving antenna discharge in passing to earth broke down the insulation of the filings of the coherer, so that the local battery current could pass in the circuit, including a magnet *M*, and so record the signal. The liquid barretter of Fessenden, the various forms of rectifying crystal detectors and magnetic detectors, have been extensively used. Our time does not permit a detailed description. Fig. 25 indicates at *C* a crystal detector rectifying the impulses from antenna *A* so as to work a high-resistance telephone receiver *T*, to which the operator listens. Fig. 27 shows the same apparatus, but connected inductively to the antenna circuit by a transformer.



Figs. 25, 26 and 27.

Fessenden found that if the succession of decaying wave trains reaching the telephone *T* was such as to produce a low note, the signals were easily drowned by extraneous noises or induced effects. He found that the human ear reached a maximum of sensitiveness at about 900 waves of sound per second, so that the signals were heard distinctly when otherwise they would have been missed. This is the meaning of the substitution of dynamos of about 500 cycles for exciting the wireless antenna in place of the ordinary machines of lower frequency.

The problem of wireless telephony has attracted attention for a number of years past. I well remember witnessing some of the earlier work of Fessenden in this fascinating field, in which he was pioneer. The wireless telephone speech was free from all disturbing noises and interferences so common on ordinary telephone lines. Briefly, such telephony depends on the ability to control the voice waves and vary in accordance therewith the energy given out by the transmitting antenna and to do this with a fairly large output of energy.

By employing a method I described about 1892, it is possible to generate a continuous wave train by shunting a direct current arc with a capacity (condenser) in series with an inductance, the frequency rate depending on the electrical constants of these parts of the apparatus. This system, which was the subject of the United States patent taken out by me in the early nineties, has been variously called the Duddell singing arc, or later the Poulsen arc. Poulsen employed it with modifications in his system of wireless telephony. Long before this work of Poulsen, Fessenden had used a high-frequency dynamo for securing the continuous train needed. A suitable microphone transmitter was made to so alter the relations of the waves in transmitting and receiving antennæ, that voice waves could be received in an ordinary telephone connected with the receiving antenna system.

Much progress has been made in this department of wireless work, and such telephony between Europe and America may yet become practicable. Methods are being worked out whereby it may be possible to mold outputs of many kilowatts of energy so as to have them vary with the voice waves, and when this is done many problems, the solution of which now seems remote, may become solved and the results prove of great practical value. It was not, however, my intention to devote time to these later researches, but to endeavor to present to the mind's eye a view of the nature of wireless transmission which should show the similarities to ordinary transmission by wire and also the differences. Furthermore, I hope I have shown it to be evident that future transmission of energy at high efficiencies will still demand the wire core for guiding that energy to its destination.

Metric System in the British Pharmacopœia.—It is announced in the U. S. Commerce Reports, as a matter of interest to exporters of drugs and chemicals, that Great Britain has adopted the metric system in the new British Pharmacopœia, thus conforming to the usage of other countries.

NEW BOOKS, ETC.

EUGENICS RECORD OFFICE. Bulletin No. 10A. Report of the Committee to Study and to Report on the Best Practical Means of Cutting off the Defective Germ-plasm in the American Population. I. The Scope of the Committee's Work. By Harry H. Laughlin, Secretary of the Committee. Cold Spring Harbor, Long Island, New York. February, 1914.

EUGENICS RECORD OFFICE. Bulletin No. 10B. II. The Legal, Legislative, and Administrative Aspects of Sterilization. By Harry H. Laughlin. Cold Spring Harbor, Long Island, New York. February 14, 1914.

EUGENICS RECORD OFFICE. Bulletin No 11. Reply to the Criticism of Recent American Work by Dr. Heron of the Galton Laboratory. By C. B. Davenport and A. J. Rosanoff. A Discussion of the Methods and Results of Dr. Heron's Critique. By C. B. Davenport.—Mendelism and Neuropathic Heredity. A Reply to Some of Dr. David Heron's Criticism of Recent American Work. By A. J. Rosanoff, M.D. Reprinted from American Journal of Insanity, January, 1914. Cold Spring Harbor, February, 1914.

Before any effective plan can be devised to cut off the supply of defectives, it is obviously necessary to make a series of preliminary studies which will cover the fields of medicine, physiology, surgery, biology, anthropology, psychiatry, psychology, morals and ethics, criminology, sociology, political economy, statistics, law, history, public affairs, etc. Naturally, all these studies have not as yet been made, and before they are made it would certainly be unwise either biologically or sociologically to advocate restrictive measures. The monograph is one which ought to be in the hands of Congressmen and Assemblymen, for sooner or later our legislators will be called upon to consider the problem of restraining the propagation of our defective classes.

In "The Legal, Legislative, and Administrative Aspects of Legislation" Mr. Laughlin has analyzed existing laws, bills vetoed, and bills introduced but not passed, litigation and legal opinion, working out of existing laws, criticism of existing laws, a model law, and calculations on the working out of a proposed programme. The whole is a valuable compendium which ought to serve as a practical guide in framing suitable legislation for handling the problem of the hereditary unfit.

Dr. Heron's criticism of the eugenic work which has been done at Cold Spring Harbor has received such wide publicity and has thrown so much discredit on Dr. Davenport's investigations, that it was unquestionably wise on the part of the Cold Spring Harbor station to issue its reply to Dr. Heron's criticism of recent American work. The circulation of this reply will do much to remove the impression created by Dr Heron's strictures, and to reassure those supporters of the eugenic movement who believe that Dr. Davenport and his associates are worthy of every confidence. It is impossible in the brief space at our command to comment upon the contentions of Dr Heron and the replies made thereto by Drs Davenport and Rosanoff. Suffice it to say that anyone who takes the trouble to read the documents which Drs Davenport and Rosanoff have prepared will be satisfied that the Mendelian method offers decided advantages over the statistical method, and that in the hands of Dr Davenport and his associates it has thrown a flood of light upon the problem of heredity which would certainly have not been the case had the statistical method alone been employed.

DIE ANGEWANDTE CHEMIE IN DER LUFTFAHRT. Von Dr. Géza Austerweil. München und Berlin: Verlag von R. Oldenbourg, 1914.

This excellent monograph discusses the chemistry of balloon and aeroplane fabrics. So far as we are aware, it is the only work on the subject to be had in any language. There are probably not more than half a dozen manufacturers in the whole world who are producing aeronautic fabrics. Hence the difficulty of obtaining anything like accurate scientific data on their methods is all but insuperable. Dr Austerweil has performed a notable service in collecting together data which must prove invaluable to the industry. After discussing the historical development of gas envelopes and methods of inflating them, he passes to an exposition of the various materials which can be used in making balloon fabrics, such as gold beaters skin, fibrous materials, paper, silks, cottons, linens, ramie, etc. The succeeding chapters are devoted to the chemical effect of gases upon balloon envelopes and the permeability of envelopes to gases. The various varnishes, rubber compounds and the like which are used to secure gas tightness are admirably discussed. The second portion of the book is devoted to the manufacture of aeroplane fabrics. Different factors must of course here be considered. Strength rather than impermeability is sought, and accordingly the author points out how strength can be obtained by proper weaving and other methods. Taken all in all, this is one of the most valuable books which has appeared in the admirable series on aeronautics which the student of aeronautics has reason to be thankful that the house of Oldenbourg is publishing.

THE PANAMA CANAL. Comprising Its History and Construction, and Its Relation to the Navy, International Law and Commerce. By Reuben E. Bakenhus, S.B., Corps of Civil Engineers, United States Navy; Harry S. Knapp, Captain United States Navy, and Emory R. Johnson, Ph.D., Sc.D., Special Commissioner on Panama Canal Traffic and Tolls, 1911-1913. New York: John Wiley & Sons, Inc., 1915. 8vo.; 256 pp.; with maps and illustrations. Price, $2.50 net.

This history and description of the great Canal is so authoritative as to be to all intents and purposes official. It avoids mere impressionistic effects, but it marshals the facts in so close and comprehensive a manner as to fill a distinct need in the general literature of the undertaking. Part 1 presents the early history of the enterprise, proceeding to France's contribution and the transfer of control to the United States. Part 2 takes up the route, the design and the construction. Part 3 deals with the sanitary problem and how it was met, and gives the cost of the work and the elements of its success. In Part 4 we study the effect of the Canal upon the navy. Part 5 discusses international law in its bearing upon the enterprise, and gives the text of the three treaties. Part 6 is a masterly summary of the Canal's commercial significance, specifically stating the times and distances saved, making a forecast of the probable traffic, and considering the effect upon transcontinental railroad and water-carriage rates.

CALIFORNIA, ROMANTIC AND BEAUTIFUL. By George Wharton James. Boston: The Page Company, 1915. 8vo.; 433 pp.; with a map and 72 plates. Price, $3.50 net.

With its gold and blue binding and its many illustrations in the beauty of natural coloring, this is essentially a book for the library table. That it should attract only the casual glances such volumes are generally fated to would be a great pity. For it is as shrewd and keen as it is astoundingly many-sided. It of course gives us the old missions, the Indians, the recreations and the festivals. But it describes for us, too, Californian industries, the country's increasing influence down the years upon poets and artists and architects, and its bountiful offerings to the pleasure seeker, the health seeker, the sportsman and the automobilist. This much is promised in its lengthy sub-title, and that promise is amply fulfilled in the text. No dreary platitudes are suffered to intrude, but occasional sparkles of humor light its pages. Trees, lakes, waterfalls and mountains are panoramically displayed, and these wonders of nature are admirably balanced by the accomplishments of man. Certainly after assimilating Mr. Wharton's work, one can have little sympathy with the twelve benighted individuals who placarded a tree in the Yosemite Valley with the scroll "We are a band of disappointed pleasure seekers"—and who had the temerity to sign thereto their undistinguished names.

PATTERSON'S AMERICAN EDUCATIONAL DIRECTORY. Vol. XI. Compiled and Edited by Homer L. Patterson, President American Educational Company. New York: American Educational Company, 1914. 8vo.; 804 pp. Price, $5.

The main classification is geographical, and contains a full list of schools and colleges, with information as to their kind, the class of students admitted, their religious denomination, the year of establishment, their heads, and public school officials. A second classification arranges all schools according to kind. The complete alphabetical index makes possible an instant reference to any institution.

GEOMETRY OF FOUR DIMENSIONS. By Henry Parker Manning, Ph.D. New York: The Macmillan Company, 1914. 8vo.; 348 pp.; with diagrams. Price, $2 net.

This work brings together a wealth of references, many of them relating to facts hitherto not re[illegible] accessible. The early part of the ninete[illegible] century saw the rise of this distinctly modern branch of mathematics. Most of the ancient writers, with the possible exception of Ptolemy, spoke of the four-dimensional concept as "against nature," "a monster in nature, less possible than the chimera or centaurs." Later, there comes a suggestion that Time constitutes a fourth dimension. We have found that the now indispensable concept of the higher dimensions furnishes—to quote the author—"concise terms and expressions," and by its concrete excogitations enables us "to grasp the meanings of complicated formulæ and intricate relations." Perhaps its greatest advantage is in imparting a very real understanding of the science of geometry itself, by furnishing proofs of theorems in three dimensions and enabling us to rest more upon reasoning and less upon intuition, at the same time developing both intuition and imagination. The method employed by the author is exclusively synthetic, and is presented in popular text-book style.

THE SCIENCE AND PRACTICE OF MANAGEMENT. By A. Hamilton Church. New York: The Engineering Magazine Company, 1914. 8vo.; 535 pp.; with diagrams in colors. Price, $2.

The author has with a commendable degree of success followed Ostwald's principle of arranging known facts in the best possible order and bringing out the relations between them as clearly as possible. Only Ostwald had particular reference to chemistry, while the author's chosen field is industrial management. He assigns to this science two basic elements, the Determinative, or policy-planning in both manufacturing and distributive aspects, and the Administrative, which takes care that the policy has adequate expression in operation. He admits the prematurity of at present seeking to reduce the determinative element to a body of principles, and restricts his research to the secondary element, and to but one division of that, namely, manufacturing. Here he treats of five great organic functions, Design, Equipment, Control, Comparison, and Operation. Ripe experience combined with the closest application has gone into the making of this book, which constitutes a valuable addition to the Works Management Library.

OCEAN TRAFFIC AND TRADE. By B. Olney Hough. Chicago: LaSalle Extension University, 1914. 8vo.; 432 pp.

Although the arrangement is that of a text-book, with test questions following each section, this volume is equally well adapted for general reading. The commerce of the port of New York for 1912 was more than four times the commerce of the entire United States fifty years ago. In fact, our foreign commerce now comfortably exceeds the enormous total of two billion dollars. The author, who is editor of the *American Exporter*, compares the various services of our ocean carriers, describes shipping terms and documents, and deals with our shipping facilities, our seaports, our routes, and our charters and freight rates. He describes the method of handling import and export shipments, reviews the rise and progress of marine insurance, and sketches our maritime policy. There are chapters on shipping profits, on acquiring and developing foreign trade, and on credits and collections. The volume carries a large folding map of the world's steamship routes. Altogether the treatise marks another creditable achievement of the LaSalle Extension University, which aims to forward home study under expert guidance.

GENERAL SCIENCE. By Otis William Caldwell, Ph.D., and William Lewis Eikenberry, B.S. New York: Ginn & Co., 1914. 12mo.; 308 pp.; illustrated. Price, $1 net.

"General Science" is a text-book thoroughly modern in treatment and arrangement. Deploring the neglect of the science course by the school, and of the conflict of opinion where such courses are nominally in the curriculum, the authors offer their contribution as an already successful experiment conceived in the scientific spirit and elaborated through actual experience.

THE SPELL OF JAPAN. By Isabel Anderson. Boston: The Page Company, 1914. 8vo.; 396 pp.; illustrated. Price, cloth, $2.50 net; three-quarter morocco, $5 net.

Mrs. Anderson quotes the preamble of the Japanese narrator, "The Rustic and Stupid Wife is loth to give to the Honourable and Wise Reader these few poor notes." This sentiment certainly can not apply to her charmingly sympathetic sketches of the New Japan. To an impressionable temperament she adds a felicity of expression that results in giving us a "personally-conducted" tour of this incomparable country of islands, this land of the million swords. Its woodcarvings and lacquers, its dream gardens, its rice fields, and its brooding, slant-eyed Buddhas, all glow before us in their magic atmosphere. Its peoples pursue for us their curious occupations, celebrate their festivals, and bury their dead. The author's position as wife of the American ambassador under President Taft's administration gave her unusual opportunities that have been taken advantage of in unusual degree. It is sufficient praise to say that the resulting volume is one of the best of the Spell Series, and the attractiveness of the text is augmented by avish illustration in duogravure and in color.

THE TONSILS AND THE VOICE. In Science, Surgery, Speech and Song. By Richard B. Faulkner, M.D. (Columbia University). Pittsburgh, Penn.: The Blanchard Company. 12mo.; 400 pp.; illustrated. Price, $2.

To cut, or not to cut—that is the vexed question of the tonsils. They are useless and troublesome appendages; they have a distinct physiological function; they have no function, physiologic, biologic, chemical or phonetic; they are the origin of phagocytes that deal with deleterious substances taken into the mouth; their enucleation is followed by improved breathing and lessened liability to sore throat; they are accessory to the acoustics of the voice and accessory to the individual "*timbre de la voix.*" These varying opinions come from the pens of equally high authorities and at once indicate the difficulty of the problem to be solved. Lamperti, Shakespeare, Nordica, Lehmann, Sir Charles Santley, and a host of other teachers, singers, and physicians state in this work their experiences and their positions. The anatomy and physiology of the tonsil is lucidly dealt with, a chapter on the science of the vocal art throws many sidelights upon important phases of the subject; and some sane advice is embodied in the chapters on hygiene of the faucial tonsil and the principles of treatment. It is a work everyone should read, and one that vocalists will find particularly beneficial.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, APRIL 24, 1915

Charles Allen Munn, President
Frederick Converse Beach, Secretary
Orson D. Munn, Treasurer
All at 233 Broadway, New York

Entered at the Post Office of New York, N. Y., As Second Class Matter

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WE beg to advise our readers that we have discontinued selling numbers of the SCIENTIFIC AMERICAN SUPPLEMENT dated earlier than January 1, 1914. We removed the first week in April to the Woolworth Building, New York city, and the change in our offices precluded the carrying of issues of the SUPPLEMENT extending over a period of nearly forty years. It was, therefore, necessary to turn over this portion of the business to someone who has space for carrying so large a stock. The H. W. Wilson Company of 39 Mamaroneck Avenue, White Plains, N. Y., have been chosen to take care of our back number business. They have the complete stock, and are ready to supply any of the back numbers at the standard price of 10 cents. We, therefore, request that, in future, all orders for SUPPLEMENTS be sent direct to the H. W. Wilson Company instead of ourselves. Please do not order SUPPLEMENTS on letters ordering subscriptions for the SCIENTIFIC AMERICAN or the SCIENTIFIC AMERICAN SUPPLEMENT or books, or containing any other matters.

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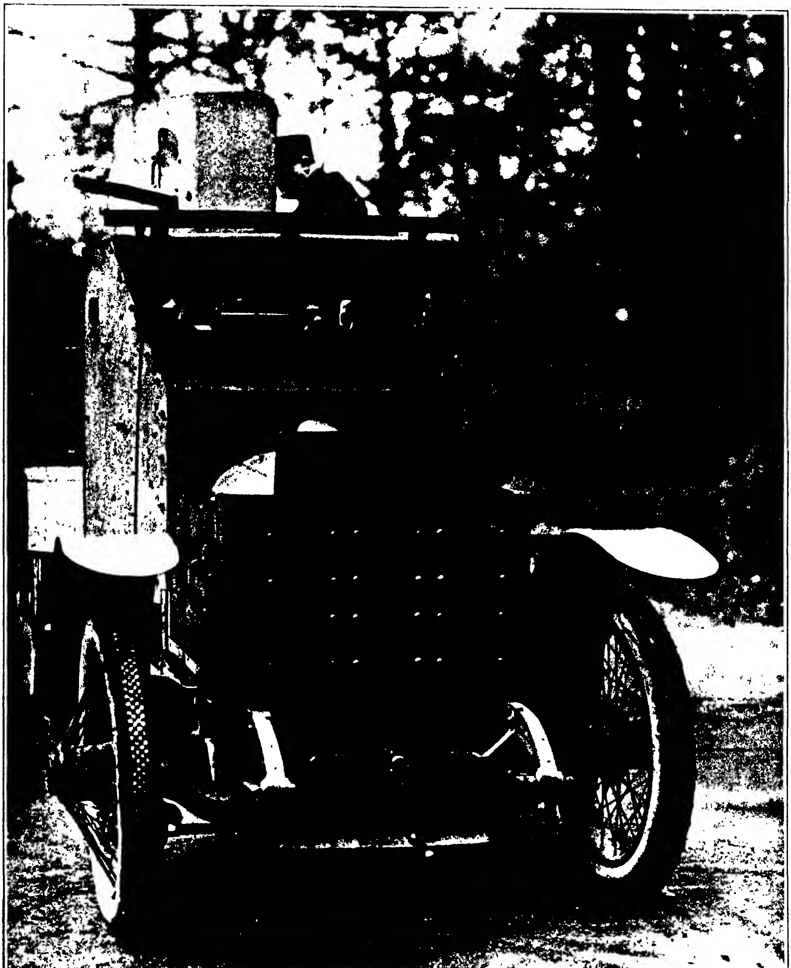
VOLUME LXXIX
NUMBER 2052

NEW YORK, MAY 1, 1915

10 CENTS A COPY
$5.00 A YEAR



BELGIAN ARMORED AUTOMOBILE WITH MACHINE GUN.—[See page 280.]

Atoms and Ions—I*

A Comprehensive Discussion Especially as Related to Gases

By Sir J. J. Thomson, O. M., F. R. S.

The subject selected by Sir J. J. Thomson, O.M., F.R.S., for his course of lectures this session at the Royal Institution is "Recent Researches on Atoms and Ions."

In his opening remarks, the lecturer said that in discussing the results of some recent investigations into the properties of molecules and ions, it was, at this stage, unnecessary to comment on the meaning attached to the word "molecule," but it might be well to define the sense in which he should use the word "ion." There was reason to believe that every charge of electricity, however large, was built up of a great number of unit charges, all equal and similar, and that we could not—do what we would—sub-divide further these small units. A unit of electricity was accordingly a perfectly definite thing, and by ion was to be understood something which carried one, two, or some other small number of these unit charges. The character of the ion was determined by the charge carried rather than by the nature of the body serving as carrier. The charges, for example, might be carried by corpuscles, by atoms, by molecules, or by larger aggregations; in fact, particles of dust acted in some cases as genuine ions. He should, as stated, limit the term "ion" to cases in which the total charge carried was at most a small multiple of the unit charge, and not apply it to bodies containing, say, one hundred or one thousand of such charges.

The conception of the ion was due to Faraday, who was led to it by his researches on electrolysis. The name was due to Whewell, who was called in by Faraday, as an expert in nomenclature, to give a name to the infant idea. Whewell further distinguished ions as "anions" or "cathions," according as the charge carried was positive or negative. These terms had, however, almost dropped out of use, and it was now more customary to use the terms "positive" or "negative" ions, as leading to less chance of confusion.

It was very difficult for those who had been familiar with the notion of ions almost from the commencement of their study of physics to realize how enormous was the step made by Faraday when he introduced the idea. It was only by stepping backwards, and noting what physics would be without this conception, that one could appreciate the enormous stride made.

Faraday's ions were ions in liquids, but in this course of lectures the speaker intended, he said, to give attention mainly to the ions found in gases. The study of ions in gases was, in fact, far easier than that of ions in liquids, and accordingly much more was known about them, although those in liquids had been studied for a much longer time. We could, in fact, form a much simpler conception of the structure of a gas than of that of a liquid, and could accordingly conceive a better picture of what was likely to go on within it. We could, moreover, alter more easily the conditions of an experiment. It was, for example, quite easy to reduce the pressure of a gas to one millionth of its original value, while it was not possible to vary the conditions in a liquid to anything like the same extent.

In the experiments he proposed to bring before the meeting he intended to use an electroscope of a type devised by Prof. Zeleny, of Yale, which, for lecture purposes, possessed very many advantages. The principle of the instrument was very simple. In Fig. 1, R denoted a plate coupled up to one terminal of a battery giving 100 volts P.D., the other terminal being earthed. In front of this plate was a strip of gold leaf G, which, it would be seen, was given a quarter twist, so that its edge, and not its side, adjoined the plate. This gold leaf was coupled up to the top plate P, above which was a collector L, connected to earth.

On coupling up the plate R to the battery, the gold leaf was first attracted up to the plate, and receiving a charge from the latter, was repelled. If any leakage of current took place between the top plate P and the collector L, the gold leaf lost its charge, and in consequence was attracted up to the plate again, to be again repelled. So long, therefore, as leakage was taking place between the top plate and the collector, the gold leaf would continue to oscillate up to the plate and away from it again.

A difficulty met with in embodying this principle in a satisfactory instrument was the liability of the gold leaf to stick to the plate when it touched it. This was one reason for mounting the gold leaf edgewise, but, even so, were the surface of the plate clean metal, a certain "coherer" action arose when the gold leaf touched it, causing the leaf to stick and preventing its repulsion. He had found, however, that this difficulty could be overcome by pasting on the plate paper treated with Indian ink. This was quite a good enough conductor, and the gold leaf would not stick if the ink used was free from too large a proportion of gum. While advantageous for lecture purposes, the instrument could, by suitably adjusting the distance between the leaf and the plate, be made almost as sensitive for laboratory purposes as the Wilson electroscope.

He should, he continued, use the lecture form of the instrument to illustrate the existence of ions and some of their properties. Charging up the instrument, he showed that with ordinary air between the top plate and the collector there was no appreciable leakage, the gold leaf being steadily repelled from the plate. If, however, the lecture were to last for a day instead of an hour, some leakage would, he said, be indicated, as ordinary air possessed some conductivity, though but on a very small scale as compared with the conductivity of gases treated in special ways. Lighting a match and letting the hot gases flow past the electroscope, the lecturer showed that the leaf began to oscillate, demonstrating that the products of combustion were capable of carrying away the charge from the electroscope, the leaf oscillating backwards and forwards several times a minute. Another method of putting a gas into the conductive state was, he proceeded, to pass it over a radio-active body. Placing a little polonium in a tube, and blowing it through this tube on to the top plate of the electroscope, Sir Joseph Thomson showed that the leaf was again set in oscillation.

He next modified the experiment by passing the air, after exposure to the polonium, through a metal tube, having a central wire connected to one pole of a battery and its wall coupled to the opposite pole. On its way to the top plate of the electroscope the air blown over the polonium had thus to traverse the electric field between the central wire and the tube wall, and he showed that the air thus treated was incapable of affecting the electroscope, while on destroying the electric field it again set the gold leaf into oscillation. Hence the conductivity conferred on the air by the polonium must be due to something which could be filtered out by the action of an electric field. This experiment afforded a convincing proof that the conductivity in question was due to charged particles mixed up with the air. That these charged particles were manufactured out of the air itself could be shown by making use of a glass vessel containing two electrodes, one coupled up to the electroscope, and the other to the earth. When this was exposed to Röntgen rays, the motion of the gold leaf showed that the air inside the bulb had become a conductor. On the other hand, if the air were removed by exhausting the vessel, there was no leakage.

Holding a little polonium near the top plate of the electroscope, the speaker showed that the effect of the polonium was limited to a definite range. If the polonium were more than a certain distance away, the gold leaf was unaffected; while it oscillated actively if this critical distance were decreased by a few millimeters.

Röntgen radiation was, he continued, only an extreme form of light, and it was therefore of interest to determine whether other forms of light had the property of producing ions. It was found that quite definite effects could, in fact, be produced by light, these effects varying with the quality of the light employed.

Placing a piece of polished zinc on the top plate of the electroscope, the speaker focussed on it, by means of a quartz lens, the light obtained by sparking between two zinc points, and showed that in this case the gold leaf was set into oscillation if the zinc was negatively charged, but that the charge was retained when the polarity of the electroscope was reversed, making the metal positive. Under the conditions of the experiment the metal could, in fact, lose a negative charge, but not a positive one. The effect, he added, was due to ultra-violet light of "a moderate character," capable of passing through a considerable space in air without great absorption and of being focussed by a quartz lens. It could not, however, pass through glass, the action being entirely stopped by interposing a sheet of glass between the spark-gap and the quartz lens.

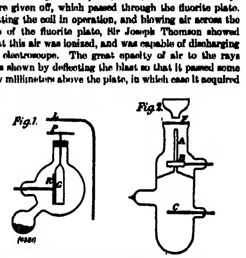
Replacing the zinc by a piece of polished brass, the lecturer showed the effect was much less marked, the leaf oscillating much more slowly.

The ultra-violet light, which thus produced these ions from metals, was not, the speaker proceeded, capable of making a gas conductive, but there was another kind of light which had the power of ionizing gases. This, known as Schumann light, was of extremely short wave-length, λ being equal to about 1,200 Angstrom units, while the light which ionized the zinc, in the experiment previously shown, had a wave-length λ of about 2,000 Angstrom units.

This Schumann light was, Sir Joseph said, very difficult to work with, most bodies being practically opaque to it, and air at its ordinary pressure would stop it within the distance of 1 or 2 millimeters; hence experiments could not be made in the open. In fact, in the experiment with the zinc, Schumann light was actually produced at the spark-gap, but was all absorbed by the surrounding air, and to get any effect from it, it would have been necessary to have had the plate almost in contact with the spark. So far as he knew, white fluorite was the only solid reasonably transparent to the Schumann rays, and in this respect the fluorite varied much in quality, some specimens being much better than others apparently identical. Colored fluorite was useless.

To produce the Schumann light, he could use a tube devised by Prof. Lyman, and represented in Fig. 2. It consisted of an exhausted bulb, divided into two compartments, communicating through the capillary tube A. Around this tube was arranged the ring electrode B, the other electrode being at C. The top of the tube was covered by the plate of white fluorite F. On coupling up the tube to a coil, a discharge of considerable intensity passed through the capillary tube, and Schumann rays were given off, which passed through the fluorite plate. Setting the coil in operation, and blowing air across the top of the fluorite plate, Sir Joseph Thomson showed that this air was ionized, and was capable of discharging an electroscope. The great opacity of air to the rays was shown by deflecting the blast so that it passed some few millimeters above the plate, in which case it acquired

Fig. 1. Fig. 2.



very little conductivity. A quartz plate placed on top of the fluorite destroyed all signs of conductivity, the quartz being opaque to the Schumann rays.

This ionization of gases by ultra-violet light touched, Sir Joseph said, on a most interesting part of his subject—viz., the connection between ordinary light and Röntgen rays. The latter ionized all gases to some extent, while he thought pure helium would be immune to the action of Schumann light, helium being, in fact, one of the hardest of all gases to ionize, probably just outside the limit at which ionization by the Schumann radiation was practicable.

There was, he said, still another method of producing ions in gases. The gases given off by heated metals, were, in fact, ionized, positive ions being produced mainly at low temperatures, and negative ones mainly at a white heat.

[Note.—A correspondent of *Engineering* makes the following comment: The lectures now proceeding at the Royal Institution recall the subject of steam condensation, where ions form the nuclei, which appear the real incentive to steam to condense upon. The second of Sir J. J. Thomson's lectures especially is pregnant with this particular phenomenon, and I fancy to see again the future *electrical* condenser for steam engines or turbines, which is neither a surface nor a mechanically operated injection condenser. To me it appears that if a receptacle, or cavity, is filled with a plentiful supply of free ions, sustained condensation might be accomplished, possibly more efficiently so than hitherto.]

(To be continued.)

* Reproduced from *Engineering*.

Lassen Peak Eruptions.—According to the *Bulletin* of the Seismological Society of America eighty-four eruptions of Lassen Peak occurred between the first outbreak on May 30th, 1914, and March 22d, 1915, or an average of one eruption every 3.5 days for the total. From May 30th to August 23d, 1914, the average interval between eruptions was 2.7 days, while from the latter date to March 22d, 1915, the interval averaged 4 days. Thus it seems that the activity of the volcano is diminishing.

Why Vocational Guidance?*

Misdirection of Abilities Avoided and Future Success Made More Certain

By Benjamin C Gruenberg †

The folks will tell you that when they went to school they had none of the new-fangled frills and vocational guidance, and they got along just as well—and some think even better Which only means that they don t know what they missed The individual s perspective does not allow him to be a judge of whether the changes that have come about in his generation are on the whole advantageous or otherwise to the community But adequate records enable us to compare conditions at various periods and judge whether the community has gained or lost, without regard to what happened to this or that particular individual

Our economic relations have undergone such rapid changes since the Civil War that most adults have not had time to re-adjust their mental attitudes to the new conditions And the younger people are dominated by the phrases and traditions of the past This is illustrated by the complacence with which we assume that all one needs for getting started in life is a job Or by the fact that so many of us acquiesce in the doctrine that the trouble with the unemployed is that they have not found their jobs Or by the currency of the notion that young men can go to some vague West ' and grow up with the country, and make a fortune as fortunes were made in the past It is these fundamental economic changes that have brought us suddenly the problem of vocational guidance, as well as the need for a complete reorganization of our whole school system

The former drift into vocations chiefly along the lines of family usage or neighborhood custom is for the mass of our younger people no longer possible The occupations themselves have disappeared in the transfer of production to the factory The neighborhood artisans have disappeared in the shifting of populations The variety of experiences has disappeared in the simplification of processes

There are no longer industries carried on in the home where the children can learn the rudiments and acquire skill through incidental participation With the concentration of the specialized work in the factories, the apprenticeship system has died out And with the simplification of individual processes trades have lost their identity and have thus been lost from the attention of the young men and women destined to occupy them

Especially noteworthy is the situation in the larger city and in the manufacturing town A combination of economic forces has brought about a condition in which there is a demand for jobs ' on the part of an army of young boys and girls and in which there are hundreds of jobs that can be as well filled by these untrained children as by older men and women The family s needs compel the sacrifice of many considerations, including the vague future of the children, to the opportunity for immediate earnings

Accordingly, boys and girls leave schools woefully lacking in even the rudiments of an education ' and enter these occupations that lead to nothing They run elevators or errands, they wrap chocolates or parcels, they open oysters or stem cherries, they 'tend stands or sweep offices, they paste labels or pull basting threads, they do a thousand other things while they are rapidly outgrowing their native plasticity and the capacity to acquire greater skill and new ideas, while they are rapidly forgetting what they learned of the three R s, and while the sources of youth s idealism are drying up

With our schools standardized under the age-long influence of the university the children attending high schools for a longer or shorter period have in most cases merely a larger amount of certain kinds of learning But they have not any more knowledge or experience of the kinds necessary to prepare them either for particular occupations or for intelligent choice of an occupation Indeed whatever influence the high schools have had has been in the direction of prejudicing pupils in favor of professional work with clerical work as a close second

We do not need to enter into the internal causes that have hitherto produced these results The net result is that the young people leave school under conditions that permit only a small fraction of them to enter upon occupations for which they are naturally fitted or for which they have the opportunity to prepare themselves

In the meanwhile our professions have become overcrowded so that the average income of a lawyer or a doctor in this country is less than the average income of a good mechanic In the meanwhile our industries have actually felt the lack of skilled workers to a very serious degree In the meanwhile the mass of workers go forth to their labors with the certainty of failure before them

It is in these complex circumstances that the vocational guidance movement has its source and its justification There is need for training up young men and women for work that has to be done but there is also need for selecting the young men and women for their occupations upon a basis more adequate than their random distribution in space and time It is impossible through resolution or legislation to abolish the blind alley occupations We can warn young people against entering such occupations we can warn parents against letting their children enter such occupations and we can legislate against the employment of girls and boys at too early an age

Our warning to the young people will be counteracted in part by the specious plea that going to work will make a man of Johnny Our warning to the parents will have to meet the pressure of economic necessity in from one-fourth to one-third of the cases Our attempt to legislate for the protection of the youth will meet the organized opposition of all who profit from the exploitation of children and low-grade labor generally

On the side of the pupils in the schools there is need for recognition of the fact that admiration for a hero is no indication of qualification to follow in his footsteps It takes more than ambition and imagination to make an artist Arthur has both but is unfortunately color blind and will have to forego color work The fact is that we have made but a bare beginning in the direction of analyzing the nature of the child with a view to finding out what kinds of work he may qualify to do But there is a great need for a development of technique and an organization of simple methods that can be applied by every teacher to the children under her immediate charge An indication of the widespread appreciation of some such need may be seen in the fact that so many charlatans succeed in separating people from their money by promising to read their characters and special abilities etc in the stars in the palm of the hand in the bumps on the head in the twists of the hand writing and in the latest photograph The world is eager for the blessing of knowing what each can best do a blessing that is denied to most of us It is the aim of vocational guidance to assist in the wider extension of this great blessing

Many steps have been taken toward the establishment of vocational guidance on a comprehensive plan But the various steps have not all been taken by any one community or school system

The gathering of information or the making of surveys seems to be the first step Many of the surveys already made in various centers of industry will yield information as to the conditions of work in certain occupations Such information needs to be constantly brought up to date by means of direct contact with the industries and by means of permanent census work carried on by departments of labor and commerce investigations of public commissions and of social workers The best surveys so far made have been conducted under the auspices of the Russell Sage Foundation The results of these investigations are unfortunately unavailable for the children in school or even for most teachers There is needed a series of simple summaries of these surveys that can be placed in the hands of pupils and teachers

The training of teachers in the use of statistical and other reports on economic and social conditions is another step forward Psychologists are conducting experiments with a view to devising formal tests that are on the one hand simple enough to be used by ordinary teachers working with children in large numbers and on the other hand searching enough to indicate at least in a general way the main types of capacity possessed by children in such varying degrees

Many cities and towns have established differentiated courses of study in the upper elementary grades calculated to give girls and boys a chance to try out their varying powers in actual work This movement is likely before long to become a commonplace in all progressive school systems Indeed the great educational revolution in the near future is most likely to modify the school course in such a manner that from term to term the individual child will be showing the teacher just what he can do best and just what he needs most to be taught

A consideration of all that is implied by vocational guidance must be of interest to every social and economic reformer as well as to the progressive teacher If we can imagine the schools so organized and conducted that each child s abilities are early recognized and then fully developed that each child stays in school and does useful educative work to the age of eighteen years or later we can see some of these implications We should in the supposed case be confronted with the fact that the public school trains each child for useful service while the public has not the means to assure to each of its graduates an opportunity to exercise his talents and skill In the second place we should be confronted with the alternative of refusing to ruin children by sending them into occupations that are obviously destructive of the best in human life or of refusing to ruin the industries by withholding from them the children At present neither the public at large nor the teachers in school recognize that this choice of courses lies before us When the study of vocational guidance becomes the serious concern of the public schools society will become conscious of some of its basic troubles

* From the *Middle West School Review*

† Secretary Vocational Guidance Association of New York

Whetstones in the United States National Museum

Not many people realize that there is a special sort of whetstone for nearly every purpose The proper sharpening stones or abrasives for use in various professions and trades and in household work are exhibited in the division of mineral technology of the United States National Museum at Washington, D. C

Probably the first stone used for abrasive purposes was sandstone, and it is still used to-day Its coarse grit and even grain first attracted attention, while the rough edge that it gave was all that was then required

The hard, white, compact sandstones found near Hot Springs, Arkansas, are among the best whetstones known, equaling, if not surpassing, the Turkey stone which for years has been considered one of the best This Arkansas stone is known as Novaculite, and occurs in two or three grades, suitable for use with certain tools. The hard, flint-like stone should be used only to sharpen instruments made of the very best steel requiring very keen edges and points, such as those used by surgeons dentists and jewelers Other grades although composed of the same ingredients are more porous, the sand grains are not as close together and a rougher edge is given to the sharpened tool Because of their more porous nature, these stones cut faster proving suitable for the finer edged tools of carpenters machinists and engravers, and for honing razors

Indiana and Ohio supply a whetstone made from a sandstone of a coarser grain than the Novaculite of Arkansas, but nevertheless quite uniform It may be used with either oil or water, and is useful for sharpening household cutlery, penknives or ordinary carpenters tools But since it is easily cut and grooved by hard steel, the fine instruments of dentists and surgeons should not be edged or pointed on this stone

Scythestones and mowing machine stones are practically all made from mica schist rocks found in New Hampshire and Vermont These rocks are generally of a dark gray color and composed of very thin sheets of mica and quartz crystals interlaminated The grit of the schist is not as sharp as that of the sandstone because it contains foreign material other than silica which prevents the quartz grains from abrading freely Mica schist stones wear down quickly from constant use—an advantage rather than a disadvantage for as they wear down more of the hard silica grains are exposed to do the sharpening Neither oil nor water is needed to keep the pores of the stone open as with other whetstone rocks Scythes require stones with these qualities Some of the fine grained schists which produce well finished edges are made into carpenters bench stones —*Bulletin of the Smithsonian Institution*

The United States fleet collier Jupiter has thirteen cargo holds to be used both for oil and coal. She is distinguished by her peculiar booms and transfer rigging supported from towers.

Coaling United States Warships

By Special Vessels With Ingenious Fittings to do the Work Rapidly

COAL is as necessary to a battleship as gunpowder for without power of propulsion it can neither bear its adversary nor protect itself by maneuvering to avoid dangerous positions. And as the fleets of the United States are liable to be required to operate for long periods of time at a considerable distance from any port where a supply of coal could be procured, even if a vessel could take the time to go to a port, our Navy Department has devoted a great deal of time and study to the development of a system by which the necessary fuel could be furnished to its fighting ships at any place and promptly enough to maintain their efficiency.

A number of extemporized colliers fitted with various systems for handling and transferring coal have been experimented with at various times, but since 1908 a fine fleet of vessels of this class equipped with improved apparatus has been developed, and one of the largest and best of these, the Jupiter, is illustrated. This ship has a displacement of 20,000 tons, a speed of fourteen knots, and can carry a cargo of nearly 10,000 tons of coal besides a large quantity of fuel oil. To accomplish this a number of the compartments into which the hold is divided are made oil tight to enable the liquid fuel to be carried. Besides these several compartments of the double bottom have also been made oil tight. There are thirteen holds for coal and oil, the liquid fuel being carried in eight of these arranged in pairs on each side of a forward and aft bulkhead with the necessary cofferdams. The holds for coal, however, extend the whole width of the ship, being of the self trimming type. The propelling machinery is arranged aft and the coal bunkers are between the cargo holds and the machinery compartment. The total cargo capacity is 906,265 gallons of oil and 9,856 tons of coal, or alternatively 405,617 gallons of oil and 11,377 tons of coal.

The Navy Department now has seven vessels of this type and capacity, besides several others of six and eight thousand carrying capacity. There are also now under construction two fourteen thousand ton vessels built especially for carrying fuel oil, each with a capacity of 7,500 tons.

The apparatus for handling the coal and transferring it to another vessel consists of a series of steel framed towers, seven of which are erected in the waist of the ship, one between each pair of cargo hatches, and an additional one on the after superstructure to serve the after hold. Between towers six and eight there is a fore-and-aft trolleyway of semi box girder construction to enable the coal from the aftermost hold to be transferred to the No. 1 bunker either for trimming purposes or to furnish fuel for the vessel. At each corner of these towers is fitted a strong boom 55 feet long by means of which coal can be delivered twenty feet beyond the side of the vessel and at a height that will clear the superstructure of any existing battleship.

When not in use these booms are topped up vertically close to the towers, where they are secured by pins and wire preventer stays, but when handling coal they are lowered to a suitable angle where they are supported by wire topping lifts and held in their fore and aft positions by wire rope guys. Across from the tip of one boom to that of the opposite boom on the same side of the tower extends an athwartship cable-span that acts as a track for the trolley from which the one-ton clam shell bucket is suspended, and by means of which the bucket may deliver on either side of the ship. For each pair of booms with their trolley and bucket there are two operating winches located within the base of the tower, one of which has two drums for opening and closing and for holding the bucket, while the other winch has a single drum for traversing the bucket from one side to the other. Two men are required for operating each bucket, and they are stationed on an elevated platform in the tower from which they have a clear view of all the operations and with the operating levers convenient at hand.

Starting with the bucket open and on the coal in the hatch, the operation is as follows: The bucket operator puts his right foot on his throttle and starts his engine, then throws in with his right hand the opening and closing drum, which pulls the bucket together, then throws in with his left hand the holding drum, and the two drums hoist the bucket to the desired height; he then takes his foot off the throttle and stops his engine. The trolley operator will already have his links thrown in the proper position, and when the bucket comes up clear of the hatch he starts his engine by putting his left foot on the throttle lever, and when he has moved the bucket over the deck of the battleship, he takes his foot off the throttle and stops his engine; he then throws his links into the reverse position for the return trip. As soon as the bucket is over the deck of the battleship the bucket operator throws out the opening and closing drum and the bucket immediately swings open. The trolley operator then starts his engine and returns the bucket to the hatch, when he stops his engine and throws over his links for the next trip. As soon as the bucket is over

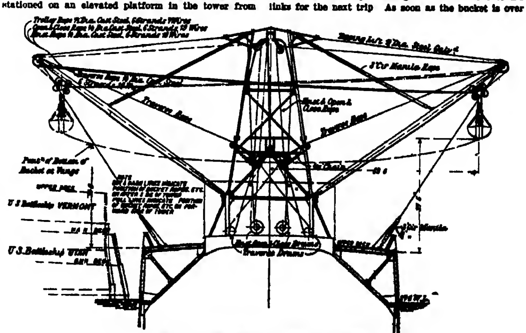


Diagram of a tower and the rigging for delivering coal.

the hatch the bucket operator releases his hoisting and holding drums, and lets the bucket drop on the coal completing the cycle. If the bucket closes as it drops the bucket operator will throw in his holding drum just before the bucket catches the coal the bucket will then open, and he can throw out his holding arm dropping the bucket on the coal

When a warship is to be coaled the collier is brought alongside, or one may be placed on each side and the work prosecuted by both at the same time With the transfer booms lowered the big buckets glide rapidly back and forth each one delivering the coal at the rate of one hundred tons an hour either into the chutes leading to the bunkers, or in piles on deck whence it is later shovelled below It is evident that these operations can only be carried on when the water is comparatively smooth and the speed of coaling will depend on the number of buckets it is possible to operate So far the best work accomplished was the transfer of 568 tons in an hour with two colliers delivering at the same time on either side of the warship

Coaling ship is always a dirty and disagreeable operation to those who are thereby employed and is rushed through as rapidly as possible On such occasions it is customary to turn out the ship's band which stimulates and cheers the men on with lively music

The Rifling of Firearms*

Why It Is Necessary, and Some of the Principles Involved

Accuracy of fire and effective action of shots are the two most important properties that a cannon should possess These requirements are met by using as heavy a projectile as possible and giving it a nearly uniform trajectory in which all irregularities that it is impossible to eliminate can be satisfactorily calculated or estimated

Of these irregularities the greatest and the most difficult to compute are caused by the resistance opposed by the air which varies with the force and direction of the wind the height of the barometer the temperature and humidity of the air and other weather conditions The resistance which the air opposes to spherical projectiles is very great so that a notable improvement in the art of gunnery was made by the adoption of the

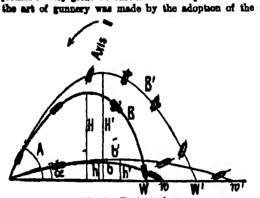


Fig 1.—Trajecteries

b B in air b' B' in vacuo a A elevation of gun h h' H H' maximum heights attained by projectile w w' W W' ranges

elongated cylindrical projectile of great weight and comparatively small cross-section This innovation however gave rise to difficulties because a long projectile tends to set itself perpendicular to its line of flight (Fig 1) This tendency may be observed in a strip of paper which held in a vertical position and let fall quickly assumes a horizontal position and flutters to the floor in a spiral path A model of a cylindrical artillery projectile mounted so that it can turn freely sets itself at right angles to a current of air blown against it

This difficulty was met by rifling the cannon and thus impressing on the projectile a rapid axial rotation and giving its axis like that of a spinning top a resistance to change in direction Rifling was invented for a totally different purpose by Augustin Kuttner who died in Nuremberg in 1630 Early in the history of gunnery it had been observed that accidental rotary movements of the spherical projectiles which were then universally employed produced deviations from the normal trajectory Attempts were made to produce similar rotations and deviations artificially by making eccentric cavities in the shot For example a cavity situated above the center of the shot at the moment of firing would produce a forward rolling rotation and the excess of the upward friction of the compressed air in front over the downward friction of the rarefied air behind would cause a continual lifting of the shot and therefore an increased range

The cannon of the 16th century were provided with straight grooves, in order to facilitate cleaning Kuttner substituted spiral grooves with the idea of overcoming

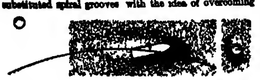


Fig. 2.—Poisson effect (inclination of projectile) exaggerated).

the resistance of the air by a boring action of the rapidly rotating projectile. The shot was cast with protuberances that entered the grooves Hence the grooves had to be quite deep, and it was very difficult to make them air tight in muzzle-loading guns The small gain brought with it a serious disadvantage and so the spiral grooves were abandoned though they were re-adopted much later for another purpose

Modern firearms are rifled with very shallow grooves of rectangular section usually equal in width to the intervening spaces or fields Their number is considerable in guns of large caliber the Krupp 40 centimeter cannon having 96 grooves The fields become flattened as they approach the loading chamber so that the projectile with its two copper guide rings can be introduced without pressure In firing the copper rings are automatically pressed into the grooves insuring perfect caulking and accurate guiding The earlier practice of caulking with leaden rings has been abandoned because of the great weight of the lead its deposition on the inner surface of the gun and the diminished splintering action of the shell

Right-hand rifling is adopted in all firearms used by the German army The shot as seen from the gun rotates in the direction of the hands of a clock The angle of rifling i e the angle between the groove and a line parallel to the axis of the bore varies within wide limits ranging from 1 to 4 degrees in long cannon with great initial velocity of projectile from 7 to 8 degrees in shorter cannon and from 5 to 6 degrees in infantry rifles (In old rifles the angle is considerably smaller) Progressive rifling beginning with a small angle at the breech and increasing the angle until the muzzle is reached is now often used The angle of rifling increases from 3 to 7 degrees in the long 15 centimeter cannon and from 4 to 12 degrees in the 15 centimeter howitzer The choice of the angle of rifling is affected by various considerations the length caliber and elevation of the gun the weight of the charge the length and construction of the projectiles etc

The rotation of the projectile which is caused by rifling produces its desired effect directly and satisfactorily only when the trajectory is nearly level A projectile discharged from a gun elevated to a high angle would have to depress its point continually in order to keep its axis in coincidence with its greatly curved trajectory The direction of the axis however is kept fixed by the

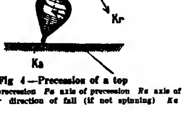


Fig 4—Precession of a top

Pk one of precession Ps axis of precession Rs axis of rotation Kr direction of fall (if not spinning) Ks axis of fall

rapid rotation of the projectile and consequently soon makes a considerable angle with the trajectory Fortunately the desired result is accomplished indirectly and automatically by the operation of certain factors which long were mysterious The rotation of the projectile and its inclination to the trajectory continue to call into action three forces of which two produce slight lateral deviations while the third continually brings back the axis to approximate coincidence with the trajectory

The inclination of the axis strongly compresses the air beneath the projectile which in consequence of its rotation rolls on this cushion of compressed air toward the right (in right-hand rifling) and deviates slightly in the same direction from its previous course This is known as the Poisson effect (Fig 2)

Another deviation called the Magnus effect (Fig 3) is brought about in the following manner When the point of a projectile having right-hand or clockwise rotation, is above the tangent to the trajectory, the air particles which are carried around the projectile by its rotation move somewhat forward on the right side and backward on the left On the right side the collisions of these whirling air particles with the backward relative air current caused by the forward motion of the projectile produce condensation and increase of pressure while the density and pressure of the air are diminished on the left side This excess of pressure on the right side causes the projectile to deviate slightly to the left The estimated amount of this effect is less than that of the opposed Poisson effect Experiment shows only a very small deviation to the right which represents the difference between the Poisson and Magnus effects

Far more important is the peculiar process by which

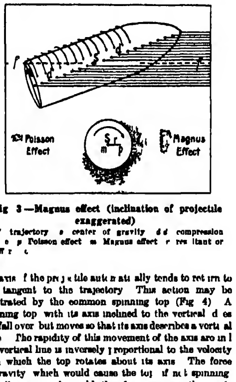


Fig 3—Magnus effect (inclination of projectile exaggerated)

ff trajectory s center of gravity dd compression so e p Poisson effect m Magnus effect r resultant or f f r t

the axis of the projectile automatically tends to return to the tangent to the trajectory This action may be illustrated by the common spinning top (Fig 4) A spinning top with its axis inclined to the vertical does not fall over but moves so that its axis describes a vertical cone The rapidity of this movement of the axis around the vertical line is inversely proportional to the velocity with which the top rotates about its axis The force of gravity which would cause the top if not spinning to fall over and would therefore increase the angle between its axis and the vertical merely rotates the plane of this angle without increasing it when the top is spinning In the case of an elongated rotating projectile with its point above its curved trajectory (Fig 5) the force of gravity is replaced by the aerodynamic force that acts to increase the angle between the axis and the path to a right angle Owing to the rapid rotation of the projectile this increase does not occur but the axis of the projectile describes a cone about the tangent to the trajectory When the axis has swept through one half of this cone it is again in the vertical plane of the trajectory Meanwhile the projectile has advanced along the curved trajectory so that the axis in its new position is nearly coincident with the tangent to the trajectory at the point which the projectile has reached In this way the deviation of the axis from the

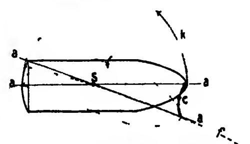


Fig 5—Precession of a projectile

f trajectory s center of gravity c arc of precession k direction of deviation a a axis of projectile a a axis after precession through arc of 180 degrees

* Extracted from Prof. Adolf Keller's article in Die Umschau, for the Scientific American Supplement.

trajectory is kept within narrow limits. Mathematical investigation shows that the point of the projectile moves in cycloidal curves.

In the projectile, as in the top, this "precessional" movement of the axis is inversely proportional to the velocity of rotation about the axis. This fact must be considered in connection with the problem of rifling. Too rapid rotation, caused by too large an angle of rifling, may in some conditions make the precession too slow to correct deviations of the axis from the trajectory. The difficulties are increased when the gun is designed for use at widely different elevations. It is evident that no sort of rifling can invert at the summit of its flight a projectile which is fired vertically upward, or can prevent such a projectile striking the ground with its base, instead of its point. Hence, in testing a given rifling, the gun is progressively elevated until the projectile strikes in this manner. The elevation thus determined, the elevation at and beyond which the rifling fails, depends upon the angle of rifling at the muzzle, the caliber and the velocity of the projectile. Regarded from this viewpoint, the new German 42-centimeter mortar represents a far higher technical achievement than appears at first glance. The great increase in caliber is not only a matter of improvement in the use of materials and in methods of construction. It also involves new calculations, based upon many long and costly experiments.

The Dyestuff Situation*

Reasons Why the Establishment of Competative Plants Would Be Poor Financial Policy

By Arthur D. Little

MANUFACTURERS of American flags are in no immediate danger of having to rely upon Cape Cod cranberries for their red or California skies for their blue. Nor is it probable that our textile manufacturers generally will be forced to adopt the suggestion that we utilize our native rainbows to supply the tinctorial requirements of their industry. Six months ago the situation was different. You could have sold rainbows by the foot. The people generally and even the consumers of dyestuffs awoke at the first declaration of war to the long patent fact that the industries of these United States are dependent upon Germany for their supplies of coloring matters, synthetic drugs and many other highly necessary products derived from coal tar. A situation which had been eminently satisfactory to consumers for many years suddenly appeared humiliating and intolerable when the embargo first threatened to cut off supplies. There were insistent demands for the immediate inauguration of an American coal-tar color industry to relieve the situation and render impossible its recurrence. It was to be established by changing the tariff and the patent laws and letting somebody else find the money. Government ownership of dyestuff plants was not considered seriously because there were no German plants interned.

With the lifting of the embargo and the resumption of shipments by way of Rotterdam most of the humiliation disappeared, while now there is even a growing disinclination upon the part of textile manufacturers to let the other fellow find the money—and make those essential changes in the tariff. The situation nevertheless remains one to cause concern and involves many factors which are worthy of your serious consideration.

All the world knows that during the last 50 years a sweeping revolution has been effected in the art of dyeing. The vegetable dyes like logwood, fustic, sumac, madder, indigo and many others, the few animal dyes like cochineal and the relatively crude mineral pigments have all been displaced completely or in greater part by the products of synthetic chemistry after a record of tinctorial service extending back to the days of Genesis. The coal-tar color industry, which began in 1856 with the discovery of mauve by an English boy of eighteen, known later as Sir William Henry Perkin, soon took root in Germany where it has attained its present great development and delicately adjusted organization mainly through the genius of a few and the plodding industry of many German chemists, the far-sighted courage of German financiers and the technical and business sagacity of German managers. It is in a very real sense a created industry brought into being by the reaction of intellect upon the black chaos of coal tar. It is peculiarly a German industry and its products for the most part may justly and proudly bear the legend, "Made in Germany."

Contrary to popular belief the products of this industry have displaced the old vegetable dyes because they are better, brighter, faster, easier of application, cheaper and incomparably wider in color range.

With our textile and paper mills, paint and varnish manufacturers, makers of printing inks, and many minor industries thus definitely committed to the use of coal-tar dyes it is not surprising that the sudden prospect of a dyestuff famine should have occasioned grave concern. At the outbreak of the war the textile mills were generally credited with having not more than five months' supply on hand. The other industries concerned were probably less fortunate. For a time the German embargo on dyestuffs prevented shipments, and stocks were rapidly depleted. Through the persistent, earnest and capable efforts of American representatives of the German manufacturers shipments have been resumed under some restrictions but with reasonable regularity. The German plants are running at about 60 per cent capacity and distribution of their product is regulated by the Government through the Society of Dyestuff Manufacturers. The basis of allotment is said to be 75 per cent of the 1913 consumption distributed over monthly shipments which must go forward in American boats. There is little doubt that to prevent re-shipment to the allies it is the German policy to keep our own mills in a chronic state of dyestuff hunger. As a result many mills are now running from hand to mouth, others claim to be provided for three months and a few for a somewhat longer period on certain lines of colors.

As a result of the close interdependence of the coal-tar dyes and coal-tar explosives industries there has been a practically complete cessation of receipts of such dyes and developers as require for their manufacture nitric acid or raw materials derived from coal tar and available for the production of explosives. Such materials for example are toluol and carbolic acid.

The acid blues and acid blacks largely used in dyeing woolens are already scarce as are also most yellows and oranges and a wide variety of blues and greens. Paranitraniline, used in connection with pigment red poster work, is practically out of the market and it may be said that pigment workers generally find themselves in an especially precarious condition as to dyes.

Nitro developers are cut off entirely and beta-naphthol is obtainable only at prices which are almost prohibitive. Within a fortnight a large gingham mill has purchased 1,200 pounds at $1.50 a pound, as against a normal price of 9 to 9½ cents.

In this connection it is only just to point out that the German manufacturers and the agents and importers here have handled the difficult and abnormal situation created by the war in a spirit of great fairness. They have prevented stocking up by greedy consumers, they have apportioned supplies impartially on the basis of past consumption, and they have shown remarkable restraint in the matter of prices. The present average advance on obtainable colors is about 25 per cent based on a 10 per cent increase in factory price and higher insurance and freights. In some cases the advance is 35 to 40 per cent. There is every prospect that with the diminution in the supply of raw materials prices will go much higher in the near future. There is a compensating, though somewhat remote, possibility that the manufacture of nitro dyes and developers may be resumed as the German government has subsidized the construction of two large plants for the manufacture of nitric acid from the air and these are expected to come into operation during the present month.

In the face of the present emergency the textile mills are resorting wherever possible to the old vegetable dyes and are already making free use of logwood and fustic. As a result these woods and their extracts have experienced a marked advance, amounting in case of fustic to 100 per cent. Paper mills are endeavoring to confine their product to natural and white papers or those which are tinted rather than deeply colored and all consumers are husbanding their color resources with the utmost care and adopting makeshifts wherever possible. It is gratifying to note that in these efforts they have the cordial and effective co-operation of the laboratories and technical staffs of the great importing agents.

In 1913 the average dividend paid by German dyestuff factories was 21.74 per cent. The actual earnings were much greater, and have sufficed in the past to provide sinking funds to cover the entire costs of development and plant. Few industries in the United States can make so good a showing. It seems reasonable, therefore, to inquire why we should endure indefinitely the present hardships and why we should not have a coal-tar color industry of our own which should supply our wants without let or hindrance from Germany. There is but one answer to these questions and but one consideration to restrain us. We can have such an industry whenever we are prepared to pay the price but is it worth that price?

The coal-tar color and explosives industry as developed by Germany is probably the most highly organized of any industry in the world. Starting with less than a dozen crude raw materials such as benzol, toluol, anthracene, napthalene, carbolic acid, etc., derived from coal tar, it builds up by complex chemical processes which often involve elaborate and expensive plants and the most rigid scientific control of operating conditions more than nine hundred separate ultimate products and over three hundred intermediates, so called, or over twelve hundred products in all, some of which cannot be turned out commercially in quantities much over 100 pounds. The whole system of production depends for its commercial efficiency upon the close correlation and interdependence of these many products. The industry is self-contained. It makes its own crudes and converts its own wastes into raw materials for new processes to be applied to them by itself. The adjustment of the economic balance is so close that a slight change in the value of some one product may disarrange whole series of processes and affect disastrously many products. Obviously, therefore, at this stage of its development, the industry must be considered as a whole if any effective competitive development in this country is to be attained. The situation is not unlike that now existing in our packing industry, where, by rougher methods indeed, but on a far greater scale, the entire raw material is utilized in a complex series of related products which are individually profitable only because of their relations to the others.

Twenty-two factories are involved in the German dyestuff industry but by far the larger portion of the business is in the hands of four great companies. The industry as a whole is bound together by trade agreements and co-operative arrangements which add greatly to the efficiency of production.

A few figures regarding one of these companies are instructive. For transportation within the plant it utilizes 42 miles of railroad. Its water works supply 10 billion gallons yearly and its ice factory 12,000 tons of ice. It has 400 steam engines, 500 electric motors, nearly as many telephone stations, and 25 steam fire engines. It has a frontage on the Rhine of 1½ miles and handles sulphuric acid in tank steamers. Seven years ago it employed 217 chemists, 142 civil engineers, 8,000 workmen, and a commercial staff of 918. Perhaps even more important from the present point of view of the American business man is this significant statement published by this company:

"On looking back upon the successes which the Badische Anilin und Soda Fabrik has achieved since its foundation the management feels it to be their pleasant duty to remember gratefully the benevolent and appreciative support which their efforts have always met at the hands of the State authorities."

Within the last few weeks, Dr. B. C. Hesse, of New York, who combines in a remarkable manner the functions of the chemist and statistician, has brought together many figures which bear upon our present problem and which give some indication of the price which we would have to pay for an American coal-tar color industry.

The world's production of all coal-tar dyes is substantially $100,000,000. The annual turnover of the German plants is about $80,000,000; the plant value on various estimates is not far from $400,000,000. It will be noted that the relation of plant investment to output is extremely high, being $5 to $1. There is one works chemist to every $80,000 of output and about 50,000 employees in all. The total export value of the German product was about $55,000,000, which was distributed among 33 countries. China takes four times as much German indigo as the United States consumes. The average wage in the industry was 4.80 marks inclusive of boys, common labor and skilled labor. The average men's wage was 5.85 marks, or $1.40, which is brought by bonuses and social service to the equivalent of $1.84. The gross average export value of the 1912 dyes produced is $61,405 each, or, excepting a very few of the most important, the corresponding figure for the remaining 900 or more is $40,811. Dr. Hesse has characterised the German coal-tar color industry as "just about a one-nation business," and on this showing I would ask you if Dr. Hesse is not right.

It is nevertheless an industry which has been replete with romance and with great achievement. The syn-

*Address before the United States Chamber of Commerce, Washington, February 5th, 1915.

thesis of alizarine for example, gave a death blow to the cultivation of madder, the annual production of which 45 years ago was about 500,000 tons. Synthetic indigo upset the social economy of whole regions in India, and made available for raising food great tracts of land before devoted to the cultivation of natural indigo. These triumphs of organic chemistry unquestionably reacted throughout the entire range of German industry and did much to convert the nation to the cult of science upon which its extraordinary efficiency in material affairs is based. These considerations, coupled with the industrial miracle of the genesis of the rainbow from so unpromising a material as coal tar, enable the coal-tar color industry to make a peculiarly powerful appeal to the imagination. We would be justly proud had we developed it ourselves.

We have in a sense had a coal-tar color industry in this country for 30 years but it has failed to take deep root or flourish even under the protection of a 30 per cent tariff, and during the very period when the German industry, under the far greater stimulus of organized and persistent research, achieved its greatest technical and commercial triumphs. There are to-day four plants in the country and they make perhaps 15 per cent of the total American consumption but confine themselves to less than 100 products. They hold out no promise of extension increase in production without Government assistance to the extent of a 30 per cent *ad valorem* duty plus 7½ cents per pound specific and an effective anti-dumping clause. In this connection it might be pointed out that from 1880 to 1883 the *ad valorem* duty was 35 per cent with 50 cents specific. The present duty is 30 per cent on colors and 10 per cent on intermediates, with synthetic indigo and alizarine colors free. Under it, probably not more than 17 of the 912 German dyes are completely fabricated in this country; the remaining 83 of the 100 types claimed as American products are merely developed or "assembled" here from intermediates obtained from Germany. Were our own manufacturers to secure the entire American business it would amount to only about $10,000,000 annually—a little more than the value of the candy sold by the Woolworth stores.

Since the United States now produces 125,000,000 gallons of coal tar annually it may here be pointed out that the country already possesses a coal-tar industry as distinguished from a coal-tar color and explosives industry, and that the coal-tar industry as such has been developed here to an extent unthought of in Germany. An average tar yields 70 per cent of pitch and only 11 per cent of materials useful to the color industry. In Europe the pitch is commonly used for fuel. In the United States upon the other hand over 90 per cent of the pitch is utilized in roofing, waterproofing and road-making, while the creosote oil and naphthalene find other profitable and well known applications.

The plain underlying reason why we have been unable during 30 years of tariff protection to develop in this country an independent and self-contained coal-tar color industry while during the same period the Germans have magnificently succeeded is to be found in the failure of our manufacturers and capitalists to realize the creative power and earning capacity of industrial research. This power and this capacity have been recognized by Germany and on them as corner-stones her industries are based. As a result the German color plants are now quite capable of meeting the demands of the whole world when peace is once restored. Why, then, should we duplicate them only to plunge into an industrial warfare against the most strongly fortified industrial position in the world. Let us rather console ourselves with a few reflections and then see how otherwise we might spend our money to our better advantage.

The gross business of the Woolworth 5 and 10 cent stores in 1913 exceeded the entire export business of the whole German coal-tar color industry by $11,000,000. The sales of one mail order house, Sears, Roebuck & Co., in the same year were far greater than the total output of all these German color plants, and its last special dividend is about twice the amount of their total dividend payment in 1913. The Eastman Kodak Company, with about twice the capital of the largest German color company, the Badische, and with a Government suit on its hands, earned during 1913 net profits of over $14,000,000, or 230 per cent on its preferred stock and over 70 per cent on its common, while the Badische with "the benevolent and appreciative support" of the German government earned 45 per cent. In that year the entire German industry paid $11,000,000 in dividends. The Ford Motor Company with one standardized product does a greater annual business than all the German color plants with their 1,200 products and earns four times their combined dividend while paying three times their wages.

Now that our perspective is adjusted let us consider for a moment some of the things which might be done with the vast expenditure of effort, money and research required to establish in this country this "one-nation" industry.

We should first of all review our own almost boundless natural resources and especially should we consider our gigantic and shameful wastes. They offer opportunity for the ultimate development of a score of industries, each of a magnitude comparable to the color industry of Germany, and for the almost immediate upbuilding of hundreds of smaller enterprises relatively no less profitable. We waste for instance, 150,000,000 tons of wood a year, a billion feet of natural gas a day, millions of tons of flax straw at every harvest, untouched peat deposits fringe our entire Atlantic seaboard, beehive coke ovens flame for miles in Pennsylvania, wasting precious ammonia and exciting no comment while the burning of a $1,000 house would draw a mob. The whole south is a reservoir of industrial wealth untapped in any proper sense. We have heard these things so often that we can go to sleep while hearing them. We need to really sense them, to get before our consciousness a clear conception of what they actually mean in terms of wasted wealth and present opportunity. When we do this, and there is no better time than now, let us apply the lesson of the German coal-tar color industry to these far greater problems and solve them by the compelling agency of sustained, intensive research.

To take one illustration only, the application to the lumber industry of the south of one tenth the research energy and skill which were required to bring the coal-tar chemical industries to their present proud pre-eminence would unquestionably result in the creation of a whole series of great interlocking industries, each more profitable than that of lumbering. The south would be in position to dominate the paper market of the world, it would transport denatured alcohol by pipe line and tank steamer, make thousands of tons a day of carbohydrate cattle foods, reorganize and develop along new lines and to far better purpose its languishing naval stores industry, and find new opportunity at every hand. To do these things in one industry as well as many things as good in other industries requires generally only a little faith, sustained, courageous effort, and the appreciation by American financiers of the earning power of research.

Arthur Von Auwers*

The problems that confront the astronomer differ from those with which workers in other departments of science are engaged in many important particulars, but in none more than in the magnitude of the data involved. So great is the number of the stars, so vast, both in space and in time, the scale of their motions, that in general it transcends the powers of an individual, or even of a single observatory, to collect, within the span of a lifetime, the materials for comprehensive studies, or to collate and discuss them. Co-operation is probably more essential to progress in astronomy than in any other science.

The earliest example of co-operation on a large scale in astronomical research was the proposition brought forward by Argelander and his associates, half a century ago, for the formation of a great catalogue of all the stars to the ninth magnitude in the northern sky. At the meeting of the Astronomische Gesellschaft in 1869, when, after four years of preliminary discussion, the project was formally initiated, the plan of work adopted was the one presented by Dr. Arthur Auwers, a young astronomer, who, three years earlier, had been elected to membership in the Berlin Academy of Sciences to fill the place left vacant by the death of Encke. In view of Auwers's youth—he was then only thirty-one—this was a notable recognition of his ability. But even more significant was the fact that to him was also entrusted the all-important duty of preparing the system of fundamental star places which provided the foundation for the entire work.

It is impossible, without running unduly into technicalities, to give an adequate idea of the difficulties attending the construction of such a fundamental system of star places. It must suffice to say that it requires the highest order of ability, a profound grasp of the principles of gravitational astronomy, a comprehensive knowledge of star catalogues, rare judgment, and a mastery of detail that is given to but few minds. How well qualified Auwers was for the responsibility placed upon him is evident from the fact that the fundamental system he elaborated more than forty years ago is adopted, in all its essentials, as the foundation of the greater part of the most refined meridian circle work of the present day.

His connection with the "Astronomische Gesellschaft Catalogue" did not end with the service I have described. In addition, he undertook the observation of one of the sections or "zones" of the catalogue, producing a model work, and was soon made chairman of the commission in charge of the entire project, a position he held to the date of his death, January 24th, 1915. Its success, therefore, is in large measure due to his careful planning and wise guidance. Long before his death he had the satisfaction of seeing the original catalogue completed by contributions from no less than twelve great observatories in Europe and America, and of having the plan extended, again under his direction, well into the southern hemisphere.

G. F. J. Arthur Auwers was born in Göttingen in 1838 and received his early education in the schools of his native city. His interest in astronomy was manifested when he was still a mere boy, and even before he received his doctor's degree at Königsberg in 1862, he had made many important contributions to it both by observations and by theoretical investigations. His dissertation for the doctorate, on the variable proper motion of Procyon, placed him at once in the front rank of astronomers. In this research he struck the keynote of his future life-work, "the treatment of all questions concerning the positions and motions of the stars."

The fundamental data upon which all studies of the mechanics of the stellar universe depend are the positions of the stars on the celestial sphere, their apparent motions on this sphere (technically, their "proper motions"), their radial velocities, and their distances. The first two of these elements are derived from the star catalogues based on meridian observations. One of the most important of all star catalogues is that based upon the observations of Bradley, at Greenwich, about the middle of the eighteenth century, for these observations were the first that are at all comparable in system and in accuracy with those of modern times, and they were also superior to those of his successors for fully half a century. As the time element is of the first consequence in the derivation of stellar proper motions, Bessel, who in 1810 made the first reduction of the Bradley observations, was fully justified in giving his work the title "Fundamenta Astronomiæ." Excellent as Bessel's work was, the rapid progress of astronomy in the next half century led to a more accurate knowledge of the fundamental astronomical constants and to more refined methods in the reduction of meridian observations, and it also became evident that some of his assumptions respecting Bradley's instrument were erroneous. A new reduction was therefore highly desirable and this was undertaken by Dr. Auwers in 1866. He brought all his skill and special knowledge into play and spared no pains to insure the utmost accuracy in his work. The result of the ten years' labor it involved has been well called a "masterpiece and a model." The Auwers-Bradley catalogue at once became the starting point for all discussions of proper motions, a position it will probably hold for all time.

His fundamental system of star places, the Auwers-Bradley catalogue, and his other work in related fields, will form Auwers's most enduring monuments, but they are far from comprising the full measure of his activities. Thus, he was chairman of the German Commission for the determination of the solar parallax from the transits of Venus in 1874 and in 1882. He took the leading part in preparing the observing programmes, conducted in each year one of the expeditions sent out by the government, and personally directed the elaborate discussion of all the results—a truly monumental work which fills six large quarto volumes.

From 1878 to 1912 Auwers held the position of secretary of the Section for Mathematics and Physics in the Royal Prussian Academy of Sciences (Berlin Academy) and his tactful conduct of the manifold duties of this office, together with his unselfish and tireless devotion to the interests of the academy, were gratefully acknowledged by his colleagues at the meeting of June 25th, 1912, when they celebrated his jubilee—the fiftieth anniversary of his graduation as doctor of philosophy.

He founded the bureau of the "History of the Sidereal Heavens" (Geschichte des Fixsternhimmels), whose object it is to collect all of the meridian observations of stars since Bradley's time and to combine them into a single systematic catalogue. He was a member of the commission charged with the organization of the Astrophysical Observatory at Potsdam, and assisted in the supervision of its construction and of its management in its early years. He was also the first president of the International Association of Academies.

Auwers's commanding position in his chosen science was fully recognized in his own country and throughout the world. His own government gave him the title Wirklicher Geheimer Ober-Regierungsrat, and at the time of his death he was Kanzler des Ordens pour le mérite für Wissenschaft und Künste. For more than twenty years before his death he had been a member of the seven leading National Academies of Science in Europe and America, a distinction in which but two other astronomers of his generation shared—Newcomb and Schiaparelli.

* R. G. Aitken in *Science*.

Photograph by [illegible]

Convoy hiding in the woods from a hostile aeroplane.

Carrying supplies to the British troops.

The Motor Truck in Modern Military Service

Many Uses for Motor Vehicles, Which Have Become Indispensable in War

In future wars the motor truck will be employed extensively for carrying supplies from the railways to the front. The railway lines in the zone of action are usually destroyed soon after the beginning of hostilities, and weeks are required for their restoration. During the first weeks of the war it was almost impossible to transport supplies adequately from the uninjured parts of the railways to the front by means of horse-drawn wagons, but this essential service can be performed very well by columns of trains, each composed of a motor truck and a trailer. In this way horses are spared for other military uses, and their elimination lessens disease among the troops, as experience has proved.

The material and tactical superiority of motor transport is illustrated by the following example: A column of twenty motor trains, with their heads 50 meters apart, will occupy a stretch of 1 kilometer and will carry 180 tons, allowing 9 tons to each motor truck with its trailer. At a speed of 10 kilometers per hour a distance of 100 kilometers would be traveled in a day of 10 hours. Horse-drawn wagons, with a speed of 4 kilometers per hour, would occupy 26 to 28 hours in traveling 100 kilometers, allowing for the halts required for feeding and rest. If each wagon carried one ton, 180 wagons and 360 horses would be required for the conveyance of 180 tons, and the column of wagons, with 12 meters distance between their heads, would be more than two kilometers long.

The motor trains contemplated in this example, composed of military motor trucks and trailers of the heaviest type, would merely connect the railways with the camps, whence the service would be extended to the firing line by lighter motor trains or light motor trucks without trailers. Such light motor trucks have already been adopted in all armies, especially for carrying supplies to cavalry detachments which, advancing far ahead of the main army, urgently need a rapid and efficient transport service, not dependent upon animal traction. Although these cavalry trucks can carry two tons and can, when loaded, ascend steep grades on bad roads, they are constructed with especial reference to facility of turning and general mobility in order to avoid impeding cavalry movements, even in case of retreat.

The usefulness of the military motor truck is not limited to supplying an army with rations, fodder, weapons, ammunition, and other necessaries. The many novel technical appliances of modern warfare open additional fields of special usefulness. The newest military arm, the aeroplane corps, requires light motor trucks for the transportation of fuel, lubricants, tools, and repair materials. These trucks are similar to the cavalry trucks and are likewise built to "go through thick and thin," and to escape quickly with their freight in the event of danger. Motor omnibuses of special construction are provided for carrying the helpers required for the landing, housing, and salvage of aeroplanes. France, which has taken the lead in this special field, has experimented with motor omnibuses designed for a speed of 40 kilometers (about 25 miles) per hour, when fully loaded and manned, and even with smaller vehicles, provided with pneumatic tires, and designed for a speed of 60 kilometers (37 miles) per hour. The results of these experiments are not known, as the operations of French military aviators are hedged about with the most profound secrecy.

Airships likewise need motor trucks to carry men, tools, fuel, and lubricants. The French are now trying to supply airships with gas by means of motor trucks, each carrying a large tank of compressed gas.

The employment of the motor truck for the transmission of dispatches in the field is a subject of some complexity. This was the first military use of the automobile, which served merely as a conveyance for the dispatch bearer.

The introduction of the motor truck as a means of communication is of later date. The motor truck not only carries tools and materials for the telegraph, radiotelegraph, and searchlight corps, but is used in other ways. One European army possesses trucks, on which field telegraph and telephone cables are coiled on drums, which are wound up by the motor when the line is removed. The truck may also carry a dynamo, driven by the motor and supplying current for a radio or searchlight station or for charging telegraph and telephone storage batteries. A Russian military truck has its motor mounted on a detachable part, which also carries a dynamo and searchlight, and which can be pulled or pushed, as a hand cart, up a steep hill or through a wood, which the heavy truck could not surmount or traverse. A complete sending and receiving station for wireless telegraphy and telephony, including a telescoping mast, may be constructed in automobile form.

Another very important branch of the motor truck service comprises the care and transportation of the wounded in the field. Russia has recently experimented with automobile field hospitals, equipped with all requisite medical and surgical apparatus, including a dynamo for illumination, operating Roentgen apparatus, etc. These experiments appear to have been successful, for the Russian government has ordered a number of these vehicles from Switzerland. Another Russian innovation is an automobile ambulance capable of carrying twelve or more wounded men. This is to be used for the speedy removal of wounded from the firing line. In besieged fortified places, also, these ambulances would go at night, unlighted, from battery to battery, to collect the wounded and transport them to the hospital. Similar vehicles, arranged as omnibuses, and carrying thirty passengers, have been employed experimentally in Russia for the transportation of prisoners of war.

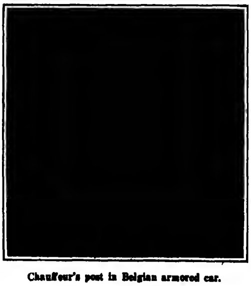
France is introducing into her field postal service motor trucks having a speed of 30 kilometers (18½ miles) per hour.

It is evident that the military motor truck has entered into new fields of usefulness, the development and exploitation of which will produce a complete revolution in transportation, communication, and equipment. It is very desirable to use the motors of these trucks for other purposes than propulsion. For several years the writer has been occupied with the development of this idea and has attentively followed the experiments in construction and application that have been made by foreign powers. It must be stated with emphasis that our Eastern and Western neighbors have devoted to special types of military automobile an attention far greater than is generally known.

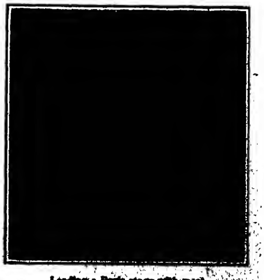
The Russian government, in particular, has ordered many vehicles of various special types during the last two years. France also exhibits great activity in this field. The automobilisation of an army is now a significant indication of the height of the war barometer.

(Abridged from the *Kriegstechnische Zeitschrift*.)

Out of the chaos of conflicting and vague reports from the European battlefields there arises clear and pre-eminent the eulogy of the automobile and motor truck. Put to the test of war conditions for the first time since its invention, with the exception of its very limited use during the last Balkan war, the gasoline-driven motorcar has more than fulfilled the expectations of its advocates. It has almost become a tiresome "bromidiom" to say that the modern motorcar has been an important factor in the rapid concentration and transportation of armies, and that but for the motor the German army could not have succeeded in advancing to within twenty-miles of Paris in the short space of four weeks. Even the most cursory reader of the daily press has been given to understand that the German attack in August was an attack by automobile.



Chauffeur's post in Belgian armored car.



Loading a Paris stage with meat.

A motor truck used by the Germans as an ambulance.

A type of car used very effectively by the Belgian army.

The attack failed; the armies have been locked in Flanders and along the eastern frontier of France for months. But the automobile has lost nothing of its importance. It has simply taken up other duties.

Military tactics to-day may be said to rely pre-eminently on the motor and its speed. Attacks reaching forward at the rate of thirty miles a day are no novelty in 1915. Retreats, in complete order, at a speed of fifty miles a day would have been called impossible by military men twenty years ago. The motorcar has revolutionized warfare. In its complete destruction of all the lore of centuries regarding military tactics it has proved as ruthless as the much-talked-of 42-centimeter siege gun of the Germans has to the fortresses of the past century.

In the case of France and Germany, the motorbuses and interurban motor passenger coaches have proved of tremendous value. Germany has an extensive system of passenger coach transportation run under the jurisdiction of the post office "mail coaches." More than 3,000 of these sturdy and capacious vehicles have been transformed into military vehicles, especially for meat transport to the front. The same must be said of the French buses, long lines of which may be seen at all times several miles behind the battle front.

The military authorities foresaw the great service that power wagons in general were called upon to perform in the event of war, and, as in all the leading countries, they endeavored to have all the power wagon trucks, including the ones used with autobus body, built according to the general standard regulations laid out by the War Department. In this way the trucks of the autobus are in reality a type of power wagon chassis which conforms to the same standard rules as apply to the larger power cars. For emergency cases or rapid maneuvers, a considerable number of troops can be instantly sent to a certain point of the battle either in autobus or on other kinds of power wagon, and this might often change the issue of events.

The popular conception of lines of infantry in trenches, interspersed with motor convoys loaded with ammunition, etc., is pure folly. Motor convoys are miles and miles in the rear of the battle line, as far beyond the range of heavy artillery fire as possible. Connection with the firing line is maintained by telephone and by motorcycle dispatch riders. In fact, the latter are pressing the automobiles hard for honors in this field.

One of the surprises of the British expeditionary forces has been the excellent showing of the fleet of 110 Foden steam trucks as heavy tractors. For slow haulage of three and more trailers, of heavy artillery, and as repair wagons with complete electrical equipment, these steam trucks have given invaluable service. They are easily kept in repair and they burn small anthracite coal as well as crude oil and kerosene.

Except on the fast cars used by the officers, pneumatic tires are strictly tabooed. Even on motor ambulances the solid rubber tire is preferred, because of the immense trouble caused by bullets or shrapnel penetrating the pneumatic—usually at the most inopportune moment. On some of the British armored cars twin pneumatics are used on the rear wheels, but in the majority of cases solid tires have been mounted. Safety in this case is preferred to a certain degree of comfort.

Motor truck experts now at the front calculate the destruction of vehicles at about 60 per cent of the total, figuring that not more than 40 per cent of the motor trucks sent to the front will ever return in condition to be useful for anything else. The estimate of the British is slightly higher, reaching nearly 70 per cent, while that of the Germans is less than 50 per cent. Several hundred good British and more than a thousand French and Belgian trucks are reported to have been repaired by the Germans in the big F. N. and Minerva automobile factories in Belgium. The Minerva plant, especially, has proven of great value to the invading army, because of its location at Antwerp, so near the scenes of fighting.

Among the special types of vehicles employed in the campaign are a number of 200 horse-power motor plows which dig trenches three feet deep faster than a hundred men can dig them with spades. Huge steam tractors with regular roller wheels for smoothing roads are used for pulling the heaviest weights, while caterpillar tractors, of the type made in the United States, pull the heaviest siege guns.

As was to be expected, reports from the various seats of war tells us of the widespread use of armored automobiles. Most of the nations involved have made exhaustive experiments to determine the most suitable of the types, which range all the way from ordinary touring cars the sides of which are covered with steel plates, to huge moving forts. The most satisfactory cars have, naturally, proved to be those between the two extremes.

The service required dictates to a large extent the design of the car. In the early days of the war, the Germans made great use of standard N. A. G. and Opel touring cars, to the sides of which are fastened steel plates of 4 millimeters thickness. No guns are mounted on the cars, the occupants being armed simply with rifles. Owing to the comparatively slight increase in weight over ordinary touring trim, these cars possess mobility of a high order and are well suited for scouting. They generally carry on each side of the dash a vertical rod having a knife-edge in front. The object of this is to sever any wires which may be stretched across the road, generally at the height of the pilot's head.

Much heavier armored vehicles have also been made use of by the Germans. These are generally trucks on which are maintained 5- or 7-centimeter Krupp or Erhardt guns. The armor plating is very heavy, being about one half inch in thickness. The rear wheels have twin solid tires and the front disk wheels have single tires of the same type.

The Belgians possess few, if any, heavily armored automobiles. They pin their faith to lightly armored, highly mobile cars, which have proved highly successful. Their speed and ease of manipulation enable them to rush to the desired spot, make a sharp attack, and, if necessary, retire quickly.

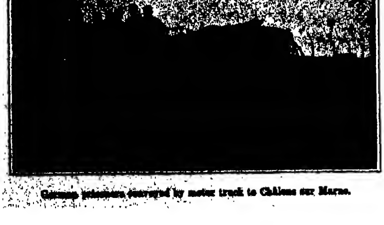
So far, little has been heard of French armored cars in the war. It is known, however, that the authorities possess a number of "traveling forts" manufactured by Charron (formerly Charron, Girardot et Voigt), and Schneider of Le Creusot.

So far as known, the English armored automobiles are merely light Daimler trucks of the subsidized type.

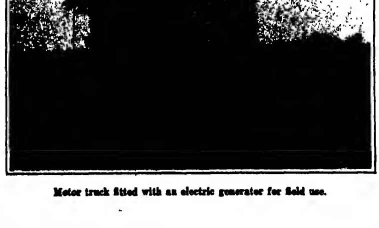
Referring to the large number of motorcars that have been reported to have failed or broken down in service, an English authority makes the following comments:

"It must be borne in mind that, so far as the British forces have been concerned, the campaign has been practically entirely over a country possessing good road systems, albeit the surfaces are not of what the foreigners calls the billiard table British type. They are surfaces, nevertheless, incomparably better than will be found either in Russia or in our dominions overseas.

"It is satisfactory to be able to record that to date a very high proportion of the vehicles that have fallen out of service with the British forces in France have done so for quite trifling reasons. Some little thing has gone wrong. The machine being but one type among a wide variety employed, there has been no opportunity to replace the small part that has failed, therefore the vehicle has perforce had to be scrapped, though a part



German prisoners conveyed by motor truck to Châlons sur Marne.



Motor truck fitted with an electric generator for field use.

weighing only a pound or two, costing perhaps a few shillings, or even a few pence, is the sole cause of the trouble.

"This means that from the point of view of the authorities the first and most important lesson of mechanical transport in connection with this war is the need of absolute standardization of types, particularly as regards interchangeability of parts.

"Every manufacturer exploits his individuality to the utmost, and seems to consider it a crime that he should produce a single part of any machine that could by chance be used in common by a maker of any other vehicle. The result is that not only for every make, but actually for every model, of motor vehicle produced in this country and employed in such operations as those of active service conditions, you require to have an entirely independent set of spare parts and equipment.

"From the campaigning point of view, of course, this is absolutely impracticable; so much so, indeed, that it is the occasion of our greatest loss of motor vehicles in the expedition to date. There will be no repetition of this trouble in future campaigns. The motor manufacturer who will not produce something more or less in common with his fellows will find little or no market for his wares.

"The causes of failure are, for the most part, so utterly trivial and so easy to avoid but for our purely insular point of view, that there is no excuse for the majority of breakdowns. Of course, the manufacturer will say on all occasions that no machine was ever designed to be abused in such fashion as obtains at the front. The answer is every time that if he cannot design and build to withstand such strains, other folk can and do.

"In this war British-built cars have not been put to any class of work that does not constitute the ordinary and every-day conditions of service away from the big cities in the United States of America and in our oversea dominions."

The Evolution of the Elements: the Evidence of the Stars

That the Various Chemical Elements Merge Into One Another by a Process of Evolution

By John W. N. Sullivan

It has been remarked that two divergent tendencies may be distinguished in the history of Science. On the one hand may be traced a synthetic process, by which we rise from a number of apparently isolated observations to a general law embracing them all and bestowing unity upon them. Such a synthesis is accomplished, for example, by the law of gravitation, which welds into one comprehensive whole such diverse phenomena as the elliptic orbits of the planets, the existence of tides, and the duration of the temperature of the sun. On the other hand, investigation sometimes proceeds from the apparently simple to the complex, of which we have a striking instance in the kinetic theory of gases, where the observed very simple laws governing the relations of the temperature, pressure, and volume of gases, is shown to be due to the very complex interactions of great multitudes of very small particles moving at random; an investigation so complex that it necessitated the creation of a new mathematical method to cope with its difficulties. Whether, on the whole, science progresses toward unity or diversity is a question on which opinion may legitimately be divided. It may be that science is doomed to failure in its great effort to reach a comprehensive survey of Nature as one great unity, and that the material universe may ultimately prove to be complex beyond the grasp of human minds. But, however that may be, it is indisputable that the recent advances in science have all been in the direction of a greater unity. The evolution of the different forms of animal life is a notion which has long been familiar to us, and we have now come to think that the chemical elements themselves have been evolved from some one primordial form. At present, if we confine our attention to terrestrial phenomena, the evidence in favor of this view is not very satisfactory, but if we turn our attention to the stars, those huge laboratories of Nature, the case assumes a different aspect. It is well known that the light emitted by each chemical element, when heated, has distinctive lines in its spectrum. Glowing sodium, for instance, has two characteristic bright yellow lines in its spectrum. If, however, light is passed through sodium vapor, two dark lines, or absorption bands, take the place previously occupied by the two bright lines. And this is general. The absorption bands characterizing the vapor of an element correspond to the bright lines emitted by the same element when luminous. By this method, the method of spectrum analysis, the chemical composition of the stars has been investigated. The dark lines observable in the spectra of the stars tell the spectroscopist at once exactly what elements make up their constitution. But this is not all. The spectrum also affords evidence as to the *temperature* of the stars, and it is the distribution of temperature and chemical constitution which has afforded such intensely interesting confirmation of the theory that the various chemical elements merge into one another by a process of evolution. As an indication of the way in which the spectrum may give evidence of temperature, let us consider the case of iron. In an ordinary Bunsen flame iron shows nothing. In the blow pipe flame iron shows the dawning of a spectrum by giving a series of bands or flutings, a "fluted spectrum," as it is called. When iron is raised to the temperature of the voltaic arc we get a true spectrum, and thousands of lines become visible. This, incidentally, points to a very complicated structure for iron, since on the electron theory each line corresponds to a specific period of vibration of the constituent electrons. If now we take iron electrodes and cause a spark to pass between them in a vacuum, the iron spectrum undergoes a remarkable change. The thousands of lines which previously existed disappear and are replaced by a few much more strongly marked lines, three of which are specially characteristic. Such lines are called the "enhanced" lines of iron, and iron in this condition is said to furnish, not a metallic spectrum, but a proto-metallic spectrum. It is evident that iron has a different constitution in these cases. It would seem that the thousands of lines in the metallic spectrum are due to the existence of a number of unstable intermediate forms which disappear in the higher energy conditions of the spark spectrum, breaking up into a small number of more stable forms. It is, however, by no means certain that the higher energy of the spark spectrum corresponds to a higher temperature. The temperature of the spark cannot be measured, and it is possible that the energy which caused the iron dissociation is almost entirely electrical. This may explain the fact that while the spectra of certain nebulæ would seem to indicate a very high temperature, yet other things do not favor this view. When certain star spectra are examined it is found that under energy conditions which cannot at present be obtained on earth, even the spark spectra of certain metals disappear, showing still more complete disruption.

We are now in a position to appreciate the fact, pointed out by Lockyer, that it is in the hottest stars that the simplest forms of matter are present, and that the incandescent bodies of the universe can be classified on this basis. The following classification was previously submitted by Lockyer in his book on "Inorganic Evolution":

Highest Temperature.

a. Gaseous Stars	Proto-hydrogen stars	Argonian Alnitamian
	Helium-gas stars	Crucian Achernian Taurian Algolian
b. Proto-metallic Stars	Rigelian Cygnian	Markabian ..... Sirian
c. Metallic Stars	Polarian Aldebarian	Procyonian Arcturian
d. Stars with Fluted Spectra.......	Antarian	Piscian

Lowest Temperature.

The termination "ian" in the above table is used to denote an epoch or stage in the process of evolution much as the same termination is used in geological evolution to denote the various strata; as in the words "Devonian" and "Silurian." The names for the stellar epochs are derived either from that of a typical bright star which possesses at the present time a temperature indicated by its spectrum, or sometimes the name of the constellation in which the star is found. Where two columns of names of stars are given, those in the first column are stars of which the temperature is at present supposed to be increasing, and where evolution would be reversed or in the direction of disintegration. The second column contains stars with decreasing temperatures, where elemental evolution toward higher atomic weights is progressing. Our own sun would be placed in this column at the level denoted by Arcturian.

It will be noticed that at the head of the list are stars called proto-hydrogen stars. These are the hottest of all observed stars (they are in the constellation Argo), and in their spectra we meet with a series of lines belonging to no known terrestrial element, but standing in relation to the known hydrogen lines. From the way in which the lines occur, they are considered to indicate a form of matter which is the precursor of the element hydrogen. Additional support for this view is obtained from the fact that there are other lines present corresponding to the lines obtained when hydrogen is sparked electrically in a vacuum tube. Lines of helium also occur, and those of proto-magnesium and proto-calcium. No lines of iron are visible here, even in the photo-form. The helium-gas stars comprise those where the spectral lines of helium are prominent, associated always with hydrogen, and where, in addition, the spectral lines of proto-carbon, oxygen, and nitrogen are clearly visible. Descending lower in the scale of temperature, we come to the proto-metallic stars. In these stars the precursors of such metals as iron, copper, manganese, nickel, titanium, and calcium make their prominent appearance in the proto-metallic form. In the metallic stars the proto-spectra become dim and disappear and we reach a temperature corresponding to that of the ordinary voltaic air-arc, as shown by the spectra of such metals as calcium, iron, and manganese. In the last class of stars we obtain fluted spectra, especially of carbon and manganese, while the lines of the metallic spectra become much fainter.

The process of elemental evolution is thus made visible to us in its successive stages, owing to the fact that the various stars open to our observation are of different temperatures and different ages. If we could extend our observations over millions of years, we should doubtless see the hottest stars, the proto-hydrogen stars, gradually changing their spectra as they evolved heavier and heavier elements, until they sank to too low a temperature to be any longer visible. With the evolution of the elements completed, we enter the region of chemical compounds and the evolution of the different forms of matter with which our daily life renders us familiar. Differing from chemical compounds, and later in their evolution, we have the colloids, the most complex of which are associated with the manifestation of life. Once life appears we enter on that steady march from the primitive protoplasmic forms to man, with which the biological theory of evolution has rendered us familiar. Such is the tremendous generalization toward which modern science is progressing. From energy combinations with the ether, producing the fundamental unit of matter, the electron, we rise through an unbroken sequence to man himself. And there we must stop. What course evolution may pursue in the future we can only very dimly see. We are the last link yet reached of a long chain, but what the ultimate destiny of man may be, who shall say?

Manufacture of Antiseptics

The following statement is issued from the Imperial Institute:

"Hitherto the manufacture of the well-known antiseptic, thymol, has been practically confined to Germany, notwithstanding the fact that ajowan seeds, the oil from which is almost the sole source of commercial thymol, are grown on a large scale only in India, which has thus been supplying Germany with the raw material of a valuable industry. No further supplies of thymol being forthcoming from Germany owing to the war, the price had increased almost eight-fold by September last, and is even now 21s. 6d. per pound, as against 5s. per pound before the war.

"There is every reason why the United Kingdom should now become the chief center for the manufacture of thymol. The manufacturing process is quite simple, and ample supplies of ajowan seed are available in India. The Imperial Institute, which has devoted attention to this subject, has now made inquiries in India, and is prepared to put intending British manufacturers of thymol in touch with Indian exporters of the seed.

"Fortunately, too, a British possession can provide a substitute for thymol if such be required. This substance is carvacrol, which is obtained from oils derived from a variety of plants, but particularly from the origanum of Cyprus. At the instance of the Imperial Institute this Cyprus origanum oil is already being produced in commercial quantities from wild plants in Cyprus, and in 1913 was exported thence to the United Kingdom to the value of £960. It is believed that the plant can be cultivated profitably and on a large scale in Cyprus, and experiments in this direction are understood to have begun."—*The London Daily Telegraph.*

Manufacture of Gasoline by "Cracking" Heavy Oils*

THAT light oils can be produced by "cracking" heavy oils has been known, and the process has been practised for many years with the object of increasing the yield of lamp-oils from crude petroleum. More recently the process has been applied to the manufacture of gasoline, which is a much more difficult operation. "Cracking" splits up the molecules of the heavy oils into simpler compounds without completely disrupting them into carbon and permanent gas, and in this way an amount of low-boiling fractions are produced that cannot be obtained by simple distillation. Two papers on the subject were read recently before the Institution of Petroleum Technologists by Prof. Vivian B. Lewes, F.I.C., and Mr. William A. Hall, respectively. The former dealt with the theory of "cracking" heavy oils, and the latter, to whose paper we are indebted for the following information, describes his own and other processes from a more practical standpoint.

There is no need for us to emphasize the importance of any process which enables gasoline to be produced from heavy oils. Such oils are available in large quantities, and are much more easily transported than highly volatile products, so that gasoline can be produced in any country. The importance of the "cracking" process may also be judged from the fact that the Standard Oil Company are operating the Burton process on a scale sufficiently large to materially affect the quantity and price of gasoline in this country, though their plant was only started on a commercial scale about two years ago, and in spite of the fact that the spirit produced by the Burton process is understood to require the addition of a considerable percentage of high-quality gasoline. In Mr. Hall's opinion the most economical source of gasoline in this country, and elsewhere, will be the gas-works where water-gas is made for illuminating purposes. For this purpose oil is used for carburetting the gas, and, instead of "cracking" all the oil into permanent gas, the operation might be conducted so as to yield 25 to 50 per cent of the volume of the oil as gasoline, leaving the balance either as substantially the same gas as would ordinarily be obtained, or as a liquid residue equal in efficiency to the gas-oil of commerce. It is thought that a gas-works could undertake the manufacture of gasoline at about one third the capital cost of a separate company, and could produce it for about 4 cents per gallon less than it could be made in any plant used solely for the purpose. There would also be considerable saving in transportation and selling costs, owing to the fact that the gas-works would be near the point of consumption, so that the total cost of the gasoline is calculated at about 10 cents per gallon.

There are two distinct methods of working, and each system has numerous ramifications. One method is to carry out the "cracking" in comparatively large stills, where the operation may, or may not, be continuous, but there is always a large volume of oil subjected to a high temperature while moving at a low velocity. It is to this class that the Burton process belongs, and, according to Mr. Hall's experience, the gasoline obtained in this way lacks uniformity. The process is also said to be slow, dangerous, and uneconomical. According to the other fundamental process, which is without these objections, the oil is "cracked" continuously while passing through heated tubes. There are, however, many difficulties encountered with tubes which are absent in the still processes. The most important of these is the deposition of carbon, which, according to Mr. Hall, cannot be avoided, so that means must be provided for removing it quickly and efficiently. In Mr. Hall's process the products issuing from the "cracking" still at a pressure of 50 to 70 pounds per square inch and at a velocity of 5,000 to 6,000 feet per minute, pass into a chamber of, say, sixteen times the diameter of the "cracking" tubes. It is found that the sudden expansion and reduction of speed throws down about 99 per cent of all the carbon formed. The carbon is deposited on short pieces of piping with which the chamber is filled, and which are removed and cleaned as required. Although the bulk of the carbon is removed in this way, some is deposited on the tubes of the "cracker," and this is most easily removed by blowing compressed air through the heated tubes, though other methods are available for the purpose.

The process is carried out as follows: The oil, which is supplied at a rate exceeding 70 gallons per hour and at a pressure of 50 to 70 pounds per square inch, is first vaporized in a coil heated by waste heat from the furnace, and is then passed into the "cracking" tubes; the latter are 1 inch in diameter, over 300 feet in length, and their temperature is about 550 deg. Cent. The velocity of the vapor in the tubes exceeds 5,000 feet per minute, which is too great for much deposit to be formed; but, at the same time, the "cracking" which occurs is not very extensive, as the vapors pass through the tubes in about 3 seconds. The vapors issuing from the "cracking" tubes pass into a vertical pipe, 12 inches or more in diameter and about 12 feet high, entering it through a very confined space, which acts as a throttle, and preferably impinging against a baffle, so that the velocity is reduced very materially. This converts the kinetic energy of the gases into heat, and the temperature rises about 30 deg. Cent., though the pressure falls to approximately that of the atmosphere. In this pipe a large amount of "cracking" takes place without the application of extraneous heat. By this method the interior of the mass is hotter than the wall of the container, and as all the vapors are passing upwards to a cooler part, local superheating is prevented; no liquid condensate has ever been collected from this chamber. The vapors next pass through dephlegmators, which separate all fractions boiling below the chosen point of cut, and the vapors and gases passing on are conducted, without further condensation, into a mechanical compressor working at 70 to 100 pounds per square inch, and then condensed through a cooler at that pressure. The compressor fulfils the double purpose of drawing the vapors through the secondary "cracking" chamber and the dephlegmators, and of chemically attaching to the condensable liquids gases which would otherwise be permanent. After much experiment Mr. Hall has abandoned the use of water with the oil, and of catalizing agents, such as nickel, as he found no advantage from either. The maintenance of the exact temperature requisite for the particular oil under treatment was, however, found to be of the utmost importance; a change of only a few degrees made enormous differences in the quality of the products and in the production of gas.

Crude "cracked" gasoline is of a yellow color, and has a peculiar varnish-like odor, due to the presence of resinous carbon colloids. Most of the latter, but not all of them, reside in the coloring matter, and, when the gasoline is refined to water whiteness, the disagreeable odor disappears, but it will frequently return on ageing, though the gasoline may remain water-white. When such a gasoline is kept for some time in contact with air, a resinous red varnish deposit is formed on the bottom of the vessel, though if evaporated over a water-bath such a deposit may not appear. A gasoline with this property would eventually clog the valves of any engine in which it might be used. Although this varnish-forming product is a result of the "cracking" process, it is not inherent to all "cracked" spirit. It is a product of high temperatures, and "cracking" can be done at temperatures so low that the product does not form to any extent. At the same time, if the temperature is reduced sufficiently to prevent the formation of resinous products, the yield of spirit may be too small for profitable working. One way of getting over the difficulty is to mix some fully saturated gasoline with the "cracked" gasoline, but this method has obvious objections. Mr. Hall's method is to work at a temperature sufficiently low to be comparatively free from the trouble, and without regard to any large conversion in the heated tubes, and then to combine the gases with the condensable vapor by the compressor, as above mentioned.

The motor fuel produced in this way is claimed to be entirely free from any objectionable odor in the liquid state, and to give an exhaust as free from smell as that from ordinary gasoline. We understand that such gasoline has been used for thousands of miles in many different motor cars without any trouble from the sooting of plugs or carbonizing of cylinders. There is said to be no more tendency to a smoky exhaust than there is with gasoline, provided a sufficient quantity of air is supplied to produce the best explosive mixture. Almost any "cracked" gasoline will give more mileage than gasoline, from 15 to 20 per cent increase having been obtained in extensive bench and road tests made by Mr. Hall. Engines run on "cracked" gasoline are also said to be free from knocking due to pre-ignition to an even greater extent than is the case with benzol. It is thought that, as compared with gasoline, the "cracked" gasoline burns more slowly and ignites more rapidly, and this is the explanation offered to account for the phenomenon.

*From Engineering.

Temperature Coefficient of Magnetic Permeability Within the Working Range

THE developments of methods and apparatus for magnetic measurements capable of an accuracy of 1 per cent makes it necessary to consider factors which have heretofore been considered negligible.

Many workers have studied the effects of temperature on the magnetic permeability of iron and steel. All of the investigations, however, have been carried on with special reference to temperatures far removed from the atmospheric range. However, a few others have made some observations at temperatures between 0 and 100 deg. Cent. which show that induction curves at two different temperatures in this region cross each other. For low inductions the magnetising force necessary to produce a certain induction decreases with increase in temperature while for high inductions it increases.

The materials examined by these investigators include soft iron, mild steel, hard steel, electrolytic iron, and nickel. Ewing[1] states that "the effects with atmospheric fluctuations of temperature exert upon the magnetic quality are too slight to require to be taken account of in specifying magnetic properties of a sample, or in stating the results of experiments." He gives curves for annealing iron wire and also for the same wire hardened by stretching beyond the elastic limit. The temperatures were 7 or 8 degrees and 100 degrees. The data show that for a given induction changes as high as 0.14 per cent per degree in permeability may occur.

In magnetic measurements at the Bureau of Standards it has been found that for magnetizing forces between 100 and 300 gausses the heating due to the current in the magnetizing coils is sufficient to change quite appreciably the induction corresponding to a given magnetizing force. For this reason it has been the practice, when making measurements where an accuracy of 1 per cent is desired, to immerse the magnetizing coils in oil, which is maintained at a standard temperature of 25 degrees. The present work was undertaken to determine what the magnitude of this temperature effect is and whether it is feasible to apply a correction for the reduction to a standard temperature of data taken at other temperatures.

Magnetic measurements at different temperatures within the atmospheric range have been made on a number of materials with different heat treatments. The results of these measurements are of such a nature that the following conclusions seem to be warranted:

1. The temperature coefficient of magnetic permeability, though small, cannot be neglected in magnetic measurements of high accuracy.

2. On account of the wide variation in temperature coefficient, not only for different materials, but also for the same material with different heat treatments, correction cannot be made to standard temperature from data obtained from other materials.

3. Unless the temperature coefficient is known for the particular material under test, temperature control offers the only means of avoiding the error due to temperature changes, at least where errors as great as 1 per cent are to be avoided. Conditions often arise in practice where the temperature of a specimen may be raised from 10 degrees to 20 degrees above the temperature of the room, due either to a comparatively heavy current or to the use of coils already heated from a previous test. Since temperature coefficients may be as great as 0.3 per cent per degree, errors amounting to 2 per cent or more may exist.

These conclusions hold in general, even though there may be materials which have very small or even zero temperature coefficients.

[1] Magnetic Induction in Iron and Other Metals, p. 178, third edition, *Bulletin of Bureau of Standards*, by R. L. Sanford.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

On page 66 of the SCIENTIFIC AMERICAN SUPPLEMENT, No. 2039, for January 30th, 1915, there is an abstract of an article published in the London *Times* on "Oil Fillers." In the tenth, eleventh, and twelfth lines you state that the water must not exceed 0.001 per cent in oil in order to obtain a dielectric strength of 40,000 volts in the standard test (0.1 inch between disks 1 inch in diameter).

This, I believe, you will find is an error either in the dielectric strength or else in the standard test. If the dielectric strength is 40,000 volts for 0.001 per cent moisture the standard test is a 0.2-inch gap between 0.5-inch disks. But if the 0.1 inch gap between 1 inch disks is the standard test, the dielectric strength for 0.001 per cent moisture will be 21,000 volts.

Pittsfield, Mass. M. E. TRESSLER.

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

I was much interested in the two calendars which you recently published. I have been working on one myself, developing one which was published in the SUPPLEMENT about thirty years ago. I have used standard tables taken from encyclopedias, and know that it is absolutely correct. I have tested it whenever I came across any old dates and have proved it to be accurate. I find several errors in the comparative table of the two calendars and also misprints.

October 11th, 1402, is evidently intended to be October 12th—a historical date which occurred on Friday.

January 10th, 372, was on Wednesday, not Tuesday.

January 10th, 572, Monday, not Sunday.

January 10th, 972, Thursday, not Wednesday.

September 2nd, 1752, old style is correct.

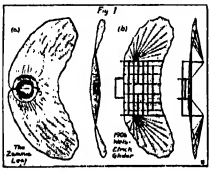
September 14th, 1752, should be new style.

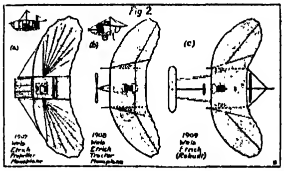
Brookline, Mass. WILLIAM S. HASELTINE.

The Evolution of the Etrich "Taube"*

How a Seed-pod Was Developed Into An Aeroplane

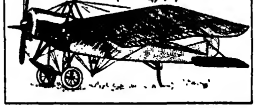
THE evolution of the Etrich "Taube" monoplane, a type upon which so many different makes of German machines are based, is not only of special interest just now on account of the prominence of the "Taube" in the daily events of the present war, but is in itself a particularly interesting subject from the historical point of view. "Taube," as no doubt, most readers know, is simply the German for dove, and, as will be seen later, the different types of Etrich machines are designated by the names of various birds, owing to the fact that the planes are wing-shaped. As a matter of fact, this design does not derive its origin from the bird, but from the seed-leaf of the Zanonia palm, which possesses remarkable gliding properties when dried. From the sketch of this leaf (a), Fig. 1, it will be seen that the seed-pod has been provided by Nature with a perfect gliding mechanism in the shape of a crescent-shaped leaf. When the leaf dries the extremities curl both laterally and longitudinally, with the result that when the seed is ripe and falls from the tree, it makes a long stable glide to the ground. This fact was noted in a brochure written by Prof. Ahlborn, and it was this which first attracted the attention of Herr Igo Etrich, an Austrian, whose father, Herr Ignaz Etrich, had started in 1898 to carry on the work of Otto Lilienthal, having bought the original gliders of that pioneer. A thorough study of the Zanonia leaf proved to be no easy matter owing to the difficulty first of obtaining specimens and then of observing the curves assumed by the leaf when gliding. However, a number of paper models were made, and the results convinced Herr Etrich that in a machine constructed on those lines would be found the solution of the problem of making a flying machine automatically stable.





In conjunction with Frans Wels, he set to work, and a large glider, 12 meter span and weighing 20 kilogrammes, was built in 1904, the framework being bamboo. With a load of 25 kilogrammes, several hundred very successful glides were made, the apparatus showing a marked degree of stability. The success of these experiments induced Etrich and Wels to go a step further and endeavor to obtain prolonged horizontal flights. To this end they constructed another model, to which they fitted a 3½ horse-power Laurin and Klement motor cycle engine. This machine had two ski-like skids, and was tested over snow, but the experiments met with little success, the machine never leaving the ground, owing, no doubt, to insufficient power and the incorrect location of line of thrust. The next move was to construct the large man-carrying glider (b) Fig. 1, and this was completed in 1906. It had an area of 35 square meters, with a span of about 12 meters, and weighed, light, 164 kilogrammes. It was built up in three sections, the central section being supported on a skid under-carriage. In the center, near the leading edge, an opening was cut in the plane for the pilot, who stood upright and held on to the cross beam in front of him. By swaying his body he could, to a certain extent, correct any rolling or pitching of the glider, caused by wind gusts, etc., but there was no other means of control. With 70 kilogrammes sand ballast numerous successful glides were made, some about 300 meters in length, while equally encouraging glides were effected with Wels on board. On October 2d, 1906, three flights of 150, 180 and 225 meters in length respectively were accomplished, the average height being about 10 meters. Four more glides were made on October 8th. All these glides were started by running the glider on a small truck down an incline of 28 per cent, the glider "taking the air" when a certain speed was reached. When gliding the speed attained was from 13 to 15 meters per second, while the gliding angle was 7 or 8 degrees.

The experiments of Santos Dumont prompted Etrich to try once more power-driven flights, this time on a larger scale, so a 24 horse-power Antoinette engine was obtained and installed in the glider as shown in (a) Fig. 2. It will be seen that the planes still followed very closely the Zanonia leaf, but in order to effect better directional control a small elevator was fitted in front close up to the leading edge, while it was also possible to flex the wing tips. The engine was mounted below the plane in the under-carriage frame, and driven by means of a chain a crude form of variable-pitch propeller located slightly below, and almost in the center of the plane, a portion of the latter being cut away so as to clear the propeller. The pilot was seated in much the same position as on the glider, and controlled the elevator by means of the pedal, the wing tips and the pitch of the propeller blades being operated by hand wheels. The under-carriage consisted of two solidly-built skids, and a pair of running wheels, supporting the plane about 1 meter above it by bamboo struts. This machine had a span of about 10 meters, and an overall length of 5.4 meters, the chord at the center being 4.25 meters. Etrich had originally intended fitting a 50 horse-power engine, but Wels favored one of smaller horse-power, and persuaded him to fit the 24 horse-power engine. The ultimate trials, however, proved that this was by no means a powerful enough engine, and once again they failed to obtain extended flights. It is true that one or two hops were made, but these, it must be owned, were due to sudden wind gusts. However, they continued experimenting along these lines, making various alterations in design. For instance, the second trials, in 1908, were made with a tractor machine (b) Fig. 2. The Zanonia-form plane remained much the same, and the 24 horse-power Antoinette engine was still employed, but the whole machine was considerably lighter. The engine was mounted forward under the plane, and drove a tractor screw direct, while the pilot sat behind the engine, also under the plane. The under-carriage consisted of a single framework to which was sprung, by means of full elliptic springs, a pair of running wheels. Behind the latter were two skids which prevented the machine from tilting over backwards. Although in some respects a distinct improvement on the previous model, this machine also was a failure, and did not appear to possess the stability of the original glider, while the advisability of fitting an elevator was also demonstrated. It was not until the next year, 1909, that Etrich, working on his own account—Wels having left him—achieved any notable success, making short flights on the old Wels-Etrich machine. He had made several alterations to this machine, (c) Fig. 2, notably the fitting of a front elevator, a rear vertical rudder, and a propeller mounted immediately behind the trailing edge. He also subsequently fitted an Anzani engine in place of the Antoinette. The first flight on this old machine was made on July 20th, when a distance of nearly 100 meters was flown, after which several other "hops" were accomplished from time to time until it "disintegrated" in September, the same year. In the meanwhile, Etrich was engaged in the construction of an improved type of machine on the Zanonia principle, for although he had made the old machine fly there was a marked lack of the stability experienced with the glider. He was, however, convinced he was working in the right direction, and his new machine, completed in the summer of 1909, bore out his convictions during its ultimate trials. Etrich I, "Sperling" or "Sparrow," (a) Fig. 3, embodied in a crude way the main characteristics of the present-day "Taube"—tractor screw, engine mounted right in front, modified Zanonia-form wings, and elevator-rudder-tail-planes mounted on a *fuselage* extending rearwards from the wings. The latter were not so crescent-shaped as those on the previous types, the leading edge being straight for more than one third the span, the wing tips swept back and only slightly up-turned. They were built up in three sections, and had a total area of 30 square meters, the angle of the incidence being 8 degrees.

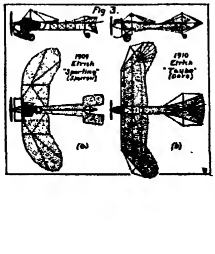


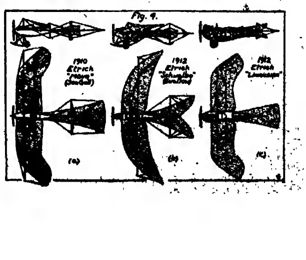
The tail consisted of a long narrow surface extending from the wings and branching into a fork at the rear, forming two rectangular surfaces. These acted as elevators, and were peculiar in that they were up-turned. In between the elevators was a vertical fan-shaped warping rudder. The whole of the tail was carried by a girder structure consisting of two longitudinals, one above the other. In its original form the under-carriage was a clumsy affair, as shown, but later a more efficient type was fitted, somewhat similar to that of the Blériot. The engine, a 53 horse-power water-cooled Clerget, was mounted in the front of the rather wide body frame, with the radiators on either side. Behind the engine sat the pilot. On this machine Etrich put up several successful flights—real flights this time—ranging from 300 meters to 4½ kilometers in length at a speed of about 70 kilometers per hour. He found it very stable, and on several occasions flew without operating the control.

From the experience obtained with this machine Etrich, during the latter part of 1909, got out the design of a second machine, Etrich II, the "Taube" or "Dove," (b) Fig. 3, which was the first of numerous subsequent "Tauben" that differed but little from the Etrich II. Illustrations of various Etrich monoplanes that have appeared in *Flight* from time to time,[1] show how the design remained practically the same throughout, the only difference being in dimensions and constructional details. Etrich II had a span of 14 meters, a supporting surface of 32 square meters, and an overall length of 10 meters. The wings had a somewhat different shape to the predecessors, the leading edge being straight for nearly the whole span, and only the extremities swept back and up-turned. They were in two sections, one mounted on either side of a covered-in body, in the orthodox style, and cable braced from a central A mast on the body. Subsequently a girder understructure, extending from the body under the wings, was employed as an additional bracing, which formed a feature of nearly all Etrich machines until quite recently. The tail consisted of a horizontal fan-shaped surface, mounted on the top of the body, with a flexible trailing edge acting as an elevator. Above and below this were two diamond-shaped vertical surfaces, which acted as fins and rudders. The engine, a 50 horse-power Clerget, was mounted in the nose of the body, and drove a tractor screw direct, while the pilot sat in a cockpit behind. The original under-carriage was of the Blériot type, with a

[1] Vol. II, p. 377; Vol. III, pp. 589 and 973; Vol. V, p. 1187; and Vol. VI, p. 899.

* From *Flight*.





central hockey-like skid. A large number of important flights were made on this machine—completed at the end of 1909—with the result that several were constructed

The next machine to be built (in 1910), however, was more or less an experiment, and differed somewhat in construction The main difference, as will be seen on referring to (a) Fig 4, consisted of the short streamline body and the landing carriage The former terminated just behind the wings, which had a similar plan-form as Etrich II, where the tail commenced—a similar practice to that followed just recently by Fokker on his monoplanes The wings were braced to a central A mast and by four king posts, a wheel being fitted to the lower extremities of each outer king post. The under-carriage consisted of a single central skid behind which was sprung a wheel. The engine, a 60 horse-power Clerget, was mounted in the nose of the body, and the pilot sat behind This machine had a span of 15 meters, a supporting area of 32 square meters and a length of 10 meters its total weight, ready for the air being 460 kilogrammes It had a speed of 80 kilometers per hour

Another experimental machine was the Schwalbe or 'Swallow' (b) Fig 4 built in 1912 The wings of this machine were almost true crescent-shape, the leading edge being curved from tip to tip They were set at a dihedral angle and upturned at the tips, and the right-hand wing had a small window formed in it close to the body The flexing elevator-tail was swallow-shape and had the usual two diamond-shaped rudder-fins above and below it The body, circular in section was built up of tubular steel longitudinals and wooden rings the whole being covered with fabric In the nose of the body was the 60 horse-power engine with the radiator immediately behind it Behind this were three seats one behind the other, the last being the pilot's The control consisted of a vertical column and wheel a backwards and forwards movement of the former operating the elevator, and a rotating of the latter actuating the rudders no wing warping was employed the flexibility of the wings alone being relied upon to maintain lateral stability The chassis consisted of a central skid connected to the body by three pairs of V struts, and a sprung axle carrying a pair of wheels The Swallow which was constructed mostly of steel had a span of 13 25 meters an overall length of 8 7 meters weighed 45 kilogrammes and had a speed of 112 kilometers per hour with three up Another machine (c) Fig 4 was a totally enclosed military monoplane built in 1912 The wings were of orthodox Etrich form cable braced top and bottom having a span of 12 meters The fish shaped body was built up of wooden channel section longitudinals and wooden rings covered with sheet aluminium from the nose to just behind the wings and with fabric for the remainder The wings were attached to the body high up and the sides of the body underneath were cut so as to form windows Inside the body were four seats two pairs in tandem the pilot being at the rear The windows were of wire gauze and celluloid A 60 horse-power Austro-Daimler engine was mounted high up in the nose of the body The under-carriage consisted of a tubular axle and pair of wheels connected to the body by four tubular steel struts Later this machine was altered the seats were placed higher up so that the pilot and passenger protruded above the body while an additional wheel was mounted under the nose Neither of these two machines showed to any particular advantage and did not therefore form an important part of the Etrich programme Fig 5 shows the latest form of Etrich monoplane The wings are of a modified Etrich form with the tips only slightly swept back and up turned They are cable-braced in the orthodox monoplane style The tail is of the hinged elevator type with a partially balanced rudder and vertical fin above it The body somewhat resembles that of the Morane Saulnier the pilot and passenger being similarly seated The engine is an 80 horse-power Gnome mounted in the nose of the body under a metal cowl The under carriage consists of a central short skid connected to the body by two pairs of V struts and a divided axle carrying a pair of wheels The outer ends of the axle are connected to the body by two shock absorbing rods

A railroad wreck crane that can be operated either by steam or electricity and lifts 120 tons.

An Electric-Steam Wrecking Crane

A COMBINATION wrecking crane built for either steam or electric power has recently been built for use in and about the Detroit River tunnel It is adapted for ordinary uses outside the tunnel as well as the special use for underground work, and to this end current for operation may be taken from a third rail, or from a flexible cable carried on the crane, but if outside the limits of the electric zone and beyond the reach of the power cable, the crane can be operated by steam from any outside source, such as an accompanying locomotive

In general the construction is like the 120-ton capacity steam wrecking cranes which are standard on American railroads. The car body is 26 feet long and 9 feet 6 inches wide, and the weight of the crane is distributed over a wheel base of 19 feet 8 inches Telescopic outriggers are provided for adding stability during heavy lifting. There are air and hand brakes with provision for both automatic and straight air The complete system is under the control of the operator, with engineer's valve, electric air compressor, etc.

No boiler is furnished with the crane, but when desired steam is taken from an outside source through a suitable system of piping. This is so arranged by means of a steam-tight slip joint at the center of revolution that the crane will slew more than 180 degrees in either direction beneath the pipe without interference. When the crane is operated by electricity this piping revolves with the crane Both the steam engine and the electric motor meet equally well all operating requirements

For electric operation there is provided a motor wound for 600 volts direct current and having a capacity varying from 200 horse-power for a short period to 115 horse-power for one hour's continuous service This motor will operate on fluctuations of line voltage ranging from 300 to 700 volts The controller is of the street railway type with cast grid resistance Current is taken from the third rail shoes through a collector ring and is delivered to a switchboard that is furnished with all necessary switches for operating the electric air compressor, cable reel third rail shoes lights, etc

An interesting feature is the automatic cable reel for paying out and reeling in the main power cable This reel has capacity for 500 feet of insulated power cable It is operated by a motor and the automatic control is obtained by the action of the motor alone without the use of any intermediate or external mechanical devices such as friction clutches, etc. This motor has current on at all times the crane is in service and taking current through the cable, so that practically constant torque is exerted by the motor with consequently practically constant pull on the cable. Any change in the pull on the cable, such as would be produced by the crane moving forward or back results automatically in the desired paying out or reeling in of the cable The motor is capable of standing stalled continuously without danger to its parts from overheating

The motions of hoisting with either the main or auxiliary hoist varying the boom radius and slewing are independent of each other and with loads up to the limit of its power these motions can be performed simultaneously With its maximum load of 120 tons the crane is capable of slewing at the rate of a complete revolution in one minute if desired of safe speed The boom may be raised or lowered under full load There is provided a special drag or pulling line connection attached to the underside of the boom When self propelled by either steam or electricity the crane has a speed of about four miles an hour but it may be safely hauled at a speed of 30 miles an hour

The maximum radius of the main block is 25 feet and the minimum is 16 feet Capacities of the crane are as follows With outriggers in position—Main hoist 240 000 pounds at 17 feet radius main hoist 160 000 pounds at 20 feet radius With end outriggers only—Main hoist 140 000 pounds at 16 feet radius auxiliary hoist, 30 000 pounds at 25 feet radius. With outriggers—Main hoist at right angles 44 000 pounds at 16 feet radius main hoist at right angles 32,000 pounds at 20 feet radius auxiliary hoist, 24,000 pounds at 25 feet radius.

The Formation of Ozone in the Upper Atmosphere—I*

And Its Influence on the Optical Properties of the Sky

By J. N. Pring, D.Sc., University, Manchester

The importance of the question of the presence of ozone in the air is due to the large influence which would be exerted by its occurrence, though only in small amounts, on the physical and chemical properties of the atmosphere. From the chemical standpoint the importance of ozone centers in its powerful oxidizing properties, in virtue of which the gas, even when diluted, quickly reacts with all organic matter, and acts as a strong bactericide. In this way ozone would be expected to take an important part in the purification of the atmosphere and in determining the salubrity of the climate. From a physical standpoint, its presence is mainly of interest on account of the influence it would exert on the transmission of light radiated from the sun. The absorption of light by ozone is particularly marked in the ultra-violet region of the spectrum. It has indeed been found by photo-electric measurements that in a column of gas 10 centimeters long, a quantity of ozone amounting to only 0.001 per cent can be detected by measuring the intensity of light transmitted. The particular wave length for which this absorption is a maximum has the value of 258 $\mu\mu$, while the band extends from about 200 to 300 $\mu\mu$. These values attain an important significance when it is considered that the solar spectrum ceases suddenly at 293 $\mu\mu$, indicating the probability that light of shorter wave-length is absorbed in the atmosphere. As the absorption of light by oxygen is not appreciable for wave-lengths greater than 200 $\mu\mu$, the above phenomenon gives evidence of the presence of ozone in the higher atmosphere. In addition to this behavior of ozone with respect to ultra-violet light, spectroscopic measurements show that this gas gives two well-defined bands in the red part of the spectrum. It is on account of this last absorption that the gas possesses a marked blue color by transmitted light.

The view has several times been put forward by chemists that ozone is present in the upper atmosphere in sufficiently large amounts to account for the normal blue color of the sky. This idea has not up to the present time been at all generally accepted, but, on the contrary, in nearly all physical researches on the optical properties of the atmosphere the presence of ozone has been ignored. This omission has arisen on account of the absence, until recently, of any definite quantitative measurements of the amount of this gas in the air, and more especially on account of the larger developments of the purely physical theories which, on quite other lines, have established some of the main factors which determine the nature of sky light.

On this physical basis it has been demonstrated by Tyndall, and deduced from dynamical principles by Rayleigh, that one factor which contributes to this color is the presence of ultra-microscopic particles of dust, which are present throughout the atmosphere, and probably of meteoric and volcanic origin. These particles, when the same order of magnitude as the wave-length of the light, exert a selective influence on the light, causing the short waves which compose the blue light to be reflected, while the longer waves, or red light, pass on. This phenomenon has also been shown to operate in the production of the greenish blue color of glacier water and certain lakes. The atmosphere is thus to be considered as a turbid medium; but this admission does not necessarily exclude other factors which might contribute to the color.

After the development of the above theory to account for the scattering of light, Lord Rayleigh drew attention to the fact that, in addition to the part played by minute dust particles in this connection, the actual molecules of air act in a similar manner, and cause a selective refraction of the light. In this way it was considered that even in the absence of larger particles of matter, the observed properties of sky light would be accounted for.

In considering selective absorption by the atmosphere, it is obvious that the phenomenon of scattering which causes reflected light to be blue leaves the transmitted light red. In consequence of this, light coming from the sky is subjected to a certain absorption causing a relative diminution in the intensity of the blue light or a relative increase of the red. This absorption is very much increased by the presence of condensed water vapor or mist in the atmosphere. The yellow or red color of the sun when near the horizon, and the coloring of clouds or mountain peaks at sunset, is clearly explained by this influence. The thickness of the atmospheric layer traversed by the rays at this time is a maximum. The absorbing influence of suspended matter present in the lower atmosphere is thus the predominant factor in determining the light from the setting sun.

If scattering the light according to Rayleigh's theory were the sole influence at work here, it would be expected that the sun viewed on the horizon would be of an invariable color. However, observation shows that the nature of this light is very variable, showing that the elements in the atmosphere which filter out the blue rays of the transmitted light are not constant. Light transmitted from the setting sun through a clear sky is frequently not so red as would be calculated from the theory of scattering. Spectro-photometric measurements have been made of light from the sun passing through a cloudless sky when viewed below the horizon from a high mountain. The nature of the light transmitted under these conditions does not generally conform to Rayleigh's law of molecular scattering, but indicates the presence of other factors of absorption.

Cases have indeed been placed on record where, in the tropics, the air was exceptionally dry, the light transmitted from the sun on first appearing above the horizon was green. This, if authentic, would definitely establish the presence of a true absorption color of air.

According to Rayleigh's theory, if the whole of the light proceeding from the sky is the result of scattering by molecules and particles which are small compared with the wave-length of light, then light which proceeds from that portion of the sky which is viewed in a direction at right angles to the direction of the sun's rays should be completely polarized. It might conversely be assumed that if all the light proceeding from this region were polarized, its origin would be solely due to the diffraction of molecules and small particles. The measurement of polarization gives accordingly a method of ascertaining definitely the part played by selective scattering. The result of such measurements is to show that the light reflected at this angle of 90 degrees is by no means completely polarized, and that the proportion of polarized to total light varies very largely from time to time.

Some recent measurements made by Boutric[1] in Switzerland have shown that the degree of polarization of light scattered at an angle of 90 degrees varied between 0.4 and 0.7 of the total light. Measurements were also made on the constant of solar radiation which is discussed below. The degree of polarization was found to vary concomitantly with these radiation values, or in other words, inversely as the absorption of the atmosphere. The variation in these values of the polarization, and deductions which have been made from measurements on the relative luminous intensities of sunlight and skylight, have shown that it is necessary to assume that a large amount of light is reflected from the sky under conditions which do not conform to the theory of selective scattering. This is probably due to the reflection of light from particles which are large compared to the waves of light, and also to some extent from direct illumination by light reflected from the earth. The admission of these sources of light opens the possibility of the operation of such factors as the color of the air itself due to elements which exert a selective absorption.

Experiments have been carried out on the degree of polarization of the light of different wave-lengths proceeding from the sky. It was found that if blue rays are removed from this light by causing it to pass through a medium of complementary color (red) so arranged that the sky appeared white when viewed through this liquid, then the light thus filtered showed exactly the same degree of polarization as when measured after proceeding directly from the sky. It would appear from this that the blue light from the sky is not polarized, but that the polarized light is white, and that the blue color results from the absorption by the air of reflected non-polarized light, or else possibly it is produced by fluorescent phenomena in the atmosphere.

Direct measurements made on the surface of the earth of the solar constant of radiation, which is defined as the radiant energy falling on unit area of the earth's surface, are of course affected by any absorption which takes place in the atmosphere. The determinations made of this constant, which is of very important astronomical significance, have shown considerable variations. Much careful research has been carried out in recent years to determine the numerical value of this constant, but on account of the varying results obtained, there is still a deal of uncertainty even about the approximate value.

Careful determinations made by Abbot and Fowle[2] in America, at an altitude of 14,500 feet, give a mean value of 1.922 calories per minute per square centimeter of the earth's surface. However, marked fluctuations, covering a range of 8 per cent, in the radiation received were observed. In all cases the values obtained agreed very closely with those made simultaneously at an altitude of 5,800 feet. It was concluded that the absorption of extreme ultra-violet rays by the atmosphere did not cause an error greater than 1 per cent in the total radiation received. The observed fluctuations were attributed to changes in the actual emissivity of the sun.

In conversation, it was suggested by Mr. R. Rossi to the writer that the fluctuations are caused by ozone. While the absorption of visible light rays by oxygen and nitrogen is negligibly small, water vapor, on the other hand, has a considerable influence. Ozone, if present in only small amounts, would act similarly in causing a marked absorption of the sun's rays. As mentioned above, the presence of this gas in the upper atmosphere has been assumed as an explanation of the fact that the solar spectrum ceases abruptly in the ultra-violet at a point where ozone is known to have a deep absorption band.

THE CHEMICAL ESTIMATION AND DISTINCTION OF SOME CONSTITUENTS OF THE ATMOSPHERE.

The further elucidation of this subject of the optical properties of the atmosphere must lie in the precise determination of the presence of such bodies as ozone, hydrogen peroxide, and nitrogen peroxide. All of these gases have been thought to be produced to a larger or smaller extent by the action of the ultra-violet light radiating from the sun on to the atmosphere, and also through the influence of ionization accompanying electrical discharges in the atmosphere, and through the possible action of electrons emitted from the sun.

Though a very large amount of attention has been devoted to this subject in the past, it has not been possible to establish with any certainty the existence of these gases in the atmosphere. The results obtained by different workers in this field have been very discordant, and very few determinations have been attempted at high altitudes. The difficulties of such an investigation arise from the small magnitude of the amounts to be measured and the great difficulty under these conditions of making any distinction between the different gases in question.

Of these gases, the one which has always offered the greatest interest in considering atmospheric phenomena is ozone, and a very large amount of work has been devoted to carrying out comparative qualitative tests on its presence in air. The means adopted for this estimation have nearly always consisted in exposing to the air absorbent papers which have been saturated with a reagent, which reacts with ozone and thereby undergoes a marked change in color. In this connection, the use of a mixture of potassium iodide and starch, which is colored blue by traces of ozone, was established by Schönbein as early as 1840, and since then a number of organic reagents have been applied in a similar manner.

An investigation was undertaken by the writer[3] in order to examine comparatively some of the chemical properties of ozone, nitrogen peroxide, and hydrogen peroxide. Methods were devised of estimating ozone when in very small quantities, and distinguishing from the other gases which show very similar chemical properties. It was found in this work that the colorimetric change which is brought about by iodine in the reaction between ozone and potassium iodide cannot be used for any quantitative deductions, and that the method is unreliable even for qualitative results on account of reactions brought about by the influence of light, by impurities in the paper, and other disturbing causes. Similar objections were found to apply to all other forms of colorimetric tests. No conclusive distinction between ozone and other gases with similar properties, which have been considered as normal constituents of the atmosphere, has been possible by any of these "test papers."

The reagent which finally was found to be most suitable for the estimation of ozone is a concentrated aqueous solution of neutral potassium iodide, the precaution being taken of protecting the liquid from the light during the measurement. This solution was found to react with ozone with great rapidity, even when the gas is

* Extracts from a paper published in *Science Progress*.

[1] *Le Radium* (1914), 11, 18.

[2] *Astro-physical Journal* (1911), 33, 191.

[3] *Chemical News* (1914), 109, 73.

very dilute. Reaction also takes place readily at temperatures as low as —80 degrees, when the gas is passed over the surface of the solidified reagent.

A careful study was made of the chemical changes which take place in this reaction, and a comparison made with those brought about by oxides of nitrogen and hydrogen peroxide. It was found that in the case of ozone, in accordance with the operation of mass action, an important influence is exerted on the nature of the products by the quantity of gas circulated and also for a given amount of ozone, by the concentration per unit volume. Thus with very dilute gas, and at temperatures above the freezing point, —24 degrees, the formation of free iodine and hypoiodite results, while with a more concentrated gas, and in all cases with the solidified reagent, in addition to these products, potassium iodate is formed directly. An estimation of the products formed in the first case can readily be made by titrating the solution with standardized sodium thiosulphate solution until the yellow color of the iodine is removed, and in the second case, the iodate can be estimated afterwards by acidifying, when decomposition into iodide and free iodine occurs, and this last is then estimated as before.

On comparing the above reactions with those given by hydrogen peroxide, it was found in this latter case that potassium hypoiodite and free iodine are formed to a limited extent, but no iodate. The reaction is not quantitative since the hypoiodite formed, when above a certain concentration, reacts with hydrogen peroxide with evolution of oxygen. Nitrogen peroxide was found to react with potassium iodide under all conditions to give mainly iodate together with some free iodine. With this last gas a very characteristic property was shown, which enabled the detection of minute traces of this gas. If in the potassium iodide solution which had been exposed to oxides of nitrogen, the free iodine, which was liberated after acidifying, was removed by titration with sodium thiosulphate, then, on standing in air, a further liberation of iodine developed with a velocity depending on the total amount of the oxides of nitrogen originally absorbed. This change is brought about through the catalytic influence of the nitrous acid formed in absorbing oxygen from the air and then undergoing reduction by the potassium iodide with liberation of iodine. This reaction enables an approximate determination to be made of these oxides when present in quantities too small to estimate by direct titration. The method thus resolves itself into a measurement of the rate at which the reagent after acidifying liberates iodine when exposed to air.

While this reaction is characteristic of oxides of nitrogen even when present with other gases, hydrogen peroxide can also be distinguished by the following separate tests. A solution of titanium sulphate in sulphuric acid is colored yellow by traces of hydrogen peroxide, and this property forms a distinguishing test for this compound.

In the case of ozone, however, it was not found possible to characterize this gas when present together with the others. An estimation could probably be made in presence of the first two gases, if very dilute, by a method of elimination. For this purpose, a determination could be made of the sum of the three gases by absorbing in acidified potassium iodide, and then deducting the quantity of hydrogen and nitrogen peroxide as determined separately.

In the measurements made in the present work, it was found that nitrogen and hydrogen peroxide are not present at high altitudes to any detectable extent, so that the problem of the estimation of ozone was considerably simplified. The manner of applying these reagents to atmospheric tests is described below.

THE ACTION OF ULTRA-VIOLET LIGHT ON AIR.

It is now a well-established fact that ozone is formed by the action of ultra-violet light on oxygen or on air, and that if initially above a certain concentration, exposure to the same light causes a decomposition of ozone into oxygen. In either of these reactions, the same stationary state is finally reached, representing an equilibrium value, when no further change in the concentration of the ozone results.

It has been found that the actual value of this equilibrium quantity varies with the nature of the light, and with the temperature and pressure of the gas. At a reduced pressure, for instance, the rate of formation of ozone is decreased and the rate of its decomposition increased, so that we find the final equilibrium is represented by a much smaller value.

Photochemical investigations have shown that light which is effective in causing the production of ozone from oxygen is limited to the region of the spectrum of wave-length below 200 $\mu\mu$. This corresponds to the observed fact that an absorption point of light by oxygen occurs at 193 $\mu\mu$ and below. It has similarly been found that rays which are effective in causing the decomposition of ozone lie in the range of wave-length between 185 and 300 $\mu\mu$, and this agrees with measurements which show that ozone absorbs light of wave-lengths up to 290 $\mu\mu$, and probably is related to the fact that the solar spectrum ceases at about this point.

The work of the writer has been devoted to the investigation of the action of ultra-violet light on air under different conditions of pressure, humidity, etc., so as to reproduce as far as possible the state prevailing in the upper atmosphere, and to obtain some idea of the concentration of ozone that can be reached in this way under different conditions. An examination was also made to see if other products, such as oxides of nitrogen and hydrogen peroxide, are produced by this action.

At the same time a large number of air analyses as described below were undertaken at high altitudes and the above compounds estimated.[4] The apparatus used for these measurements on the exposure of air to ultra-violet light was specially designed so that the air could be brought into contact with light rays which had undergone a minimum amount of absorption through intervening media between the source of light and the air. It was also arranged to prevent the temperature of the air undergoing exposure from rising to any large extent.

The nature of the light in the ultra-violet region of the spectrum radiated from the sun onto the upper layers of the atmosphere is not at all known, so that the conditions prevailing in this region could not be reproduced in the laboratory. The scope of the present experiments was consequently limited to the determination of the relative formation of the different products given under varying conditions by an arbitrary source of light.

(*To be continued.*)

[4] Cf. *Proc. Roy. Soc.* (1914).

The Planetary Nebulæ*

By Russell Sullivan

When Sir William Herschel first turned his powerful reflector to the skies, he noticed a number of small round disks of greenish light. He assumed that they were either distended stars, or comets at aphelion, or the planets which revolve around the stars. After testing these hypotheses, he cast them aside and decided that these tiny disks were hollow shells of gas.

The term "Planetary nebulæ" was used by Sir William to denote these objects and has caused confusion at times. It refers to the resemblance these nebulæ bear to the disk of a planet and not to any planetary affiliations.

In the early sixties Sir William Huggins spectroscopically examined the bright planetary nebula in Draco, which marks the pole of the ecliptic and showed that the spectrum consists of a few bright lines which indicate luminous gas under little or no pressure. This discovery, so different from the well-known continuous spectrum, might be called the beginning of nebular astronomy. Thus the spectroscope made it possible to differentiate with apparent certainty between nebulæ and distant star clusters.

In recent years the planetary nebulæ have been somewhat neglected. Little was known until Keeler visually measured the radial velocities of a few and found their average speed was about sixteen miles per second—comparable to that of the stars. This remarkable result was obtained before the days of photographic work with the spectroscope. He also attempted to measure their rotational velocity, but without definite result. If it were not for the concentration of light in a few lines the spectra of these objects would be almost invisible. Babinet's criterion, applied to a planetary nebula, would show that the rotation of a huge, attenuated mass of gas would be almost nothing at the circumference. Campbell has recently measured the radial velocity of the planetary nebulæ by the spectrographic method and confirms Keeler's earlier results obtained visually. In the last three years Campbell has found planetaries whose average speed is seven times that of the average helium star, i. e., the earliest type of star. These stars are the slowest known and have an average radial velocity of 5½ miles per second. Thus the planetaries would be moving through space with speeds of 40 miles per second. Such speeds are only comparable to the very high velocities of the faint small stars which Eddington has recently described. These stars are only visible because they are near, the distant ones being too faint for observation. Eddington finds average speeds of 42 miles per second for this class.

The number of planetaries is not large—they can be counted by the score; while the spiral type runs into the thousands. Hydrogen, helium, and nebulium (the latter terrestrially unknown) are the principal gases which form these strange bodies, and there is often a central star or haze, implying a certain degree of condensation which would contradict Herschel's theory of a hollow sphere. Some planetaries present an elliptical aspect and it is evident that others consist of two or three spheres of gas. The majority are probably spheroidal and under high powers show a mottled or slightly rugged disk. All planetaries, with a few exceptions, lie in or near the plane of the Milky Way. In fact, almost all gaseous (i. e., "green") nebulæ lie in or near the galactic plane.

There are more planetaries in the Southern Hemisphere and the available evidence tends to show that they are numerous in the Greater Magellanic Cloud. Almost nothing is known about their motion at right angles to the line of sight. The fact that few planetaries have wandered far from the galactic plane would imply that this component is small. Why should they have high speeds and still keep to the plane of the Milky Way? One would expect lower velocity in conformity with the average early type star of the galactic plane. Nor has anything been learned concerning their distance or dimensions; they are presumably very remote, as their close association with the plane of the Milky Way would imply, and in size must enormously exceed a globe whose diameter is equal to that of the solar system. Their low galactic latitude makes it certain that they are *en rapport* with the Milky Way and thus are not external to our own universe.

Stellar nebulæ seem to be small or distant planetaries. Pickering has found a number of them by sweeping with a direct-vision spectroscope; they are faint, minute and almost star-like in appearance. Miss Clerke thinks them similar to the planetaries. They are gaseous and never lie outside the plane of the Milky Way.

Wright, Merrill, and Paddock have recently found that there is a pronounced resemblance between the spectra of stars of the Wolf-Rayet type and the planetaries. At least three planetaries yield Wolf-Rayet bands. A bright planetary in Ophiuchus (N.G.C. 6572), which has a nucleus, and a Wolf-Rayet star in Cygnus (BD + 30 degrees 3639, found by Campbell to have an hydrogen envelop of 5 seconds of arc in diameter) are spectroscopically planetary nebulæ with Wolf-Rayet stars for nuclei. Both classes of spectra lack the metallic lines common to the older types of stars. The Wolf-Rayet stars are usually assigned to Type O, the beginning of stellar evolution, and have small average radial velocities, whereas the planetaries have average speeds several times as great. It is difficult to reconcile such facts. The Wolf-Rayet type is noted for its adherence to the galactic plane and a score or so of these stars lie in the Magellanic Clouds as well.

Finding Novæ often assume the planetary stage on their downward career. Bickerton thinks that they have been struck off as "third bodies" after a stellar collision and continue their existence as expanding hollow shells of gas. The Novæ have not shown positively that their nebular stage is permanent, as the majority have eventually assumed a faint continuous spectrum and have become small stars. In this connection it may be interesting to note that Novæ often show Wolf-Rayet bands in their intermediate stages, followed by the spectrum of nebulium. Thus the Wolf-Rayet and planetary spectra would appear consecutively. Miss Clerke thinks that this period is the middle of a Nova's life. Campbell suggests that planetary nebulæ originate by stellar collision or close approach. Before a star becomes a Nova the chances are that it has gone through several stages of stellar evolution and has thereby acquired a velocity comparable to that of the fast Type M Star (10½ miles per second) or the planetary nebulæ; Eddington says the speed is still greater for fainter stars of that type. If the planetaries were as numerous as the stars we might infer a genesis of planetaries from old stars. Since they are comparatively scarce, it seems more likely that they are the wrecks of ancient Novæ. The number of planetaries and Novæ is in fair agreement and both classes lie in or near the plane of the Milky Way.

Campbell arranged a number of stars in the order of their spectroscopic age and showed that the planetary nebulæ exceed the oldest stars in speed. According to Keeler, the great nebula in Orion, of the *irregular* gaseous type, is almost at rest in space. Evidently one gaseous type is much older than the other and there may be unknown stages of stellar evolution connecting the two gaseous types. If increasing radial velocity is a measure of a star's age, are we justified in applying this criterion to the nebulæ?

Thus the planetary nebulæ have Wolf-Rayet affinities and are related to the Novæ as well, the Novæ also showing an intermediate Wolf-Rayet spectrum. The interpretation of these relations is one of the tasks of modern spectroscopy.

* From *Popular Astronomy*.

Gaseous Explosions*

THE investigation of gaseous explosions is of interest to chemists, physicists, and engineers. The chemist studies the laws of combination and dissociation; the physicist deals with modes and rates of inflammation, variation of specific heat, maximum temperatures attained, and laws of radiation and cooling; while the engineer considers both chemical and physical effects as bearing on the practical operation and thermo-dynamics of the internal combustion engine. He also interests himself in the analogous phenomena of inflammable dust explosions as found in coal-mine and flour-mill accidents. The matters of interest are obviously numerous and complicated, and it is accordingly necessary to limit their consideration to a few points. The points selected will be dealt with as they bear more particularly on the engineering problems of the internal combustion engine. In 1907 the British Association, at its Leicester meeting, appointed a committee of investigation. This committee has been at work ever since, and much light has been thrown by the experiments of its members upon the facts connected with gaseous explosions as occurring in closed vessels and within engine cylinders having moving pistons. It is now proposed to describe some of the work of the committee, dealing first with the phenomena of rising temperature, and secondly with that of cooling after explosion.

When a mixture of coal gas and air is ignited within a strong closed vessel, it is found that the pressure rises rapidly, attains a maximum, and falls relatively slowly. To this rapid pressure rise is due the term gaseous explosion. Such explosions are obtained with mixtures of all inflammable gases or vapors with air or oxygen, and very similar phenomena occur with like mixtures of inflammable dust. The rise and fall of pressure is studied by means of sensitive indicator devices, which produce tracings on a rotating drum.

The pressure rise is caused by the formation of flame at the ignition point—in this case an electric spark—and the spread of this flame throughout the vessel increases the temperature of the gaseous contents, and thus increases the pressure, as in a closed vessel the volume remains constant. The rate of pressure rise is thus, broadly, the measure of the rate of the travel of the flame through the mass; and, if it be assumed that maximum pressure is attained when the whole vessel is filled with flame, then it is possible to determine the flame velocity by these measurements.

In these experiments the flame velocity for the weak mixture is about 2 feet per second, and for the strong mixture 13 feet per second. These velocities are attained in closed-vessel experiments without a moving piston. In actual engine cylinders, where the charge has been introduced at a high speed through an inlet valve, the flame velocity is much higher, and it varies with different types of engines from about 20 to 100 feet per second. The cause of this variation for similar mixtures has been the subject of investigation by Clerk and Hopkinson, and it has been definitely proved that the higher flame velocity found in working engine cylinders is due to the residual turbulence of the mixture after compression caused by the high rate of flow into the cylinder through the inlet valve. In some engines the gases forming the charge flow through the inlet valve at a rate as high as 100 feet per second. Without this increase of flame velocity in the engine cylinder it would have been impossible to run high-speed engines, such as gasoline engines, in an economical manner. At the lower flame velocity of the closed vessel the exhaust valve will be open before the pressure had time to rise. The effect of turbulence within the cylinder is marked in other respects. The rate of loss of heat from a heated platinum wire to the mass of air in the combustion space of an engine is much greater for any given point of the stroke when the engine is running fast than when running slow, and if the charge be trapped, so as to allow several compressions and expansions before measuring the heat loss, the turbulence has so died down that the conductivity diminishes.

Another point of interest in gaseous explosions is found in the fact, predicted by Clerk many years ago, but proved by Hopkinson, that the flame entirely fills the vessel before maximum pressure is attained, that is, the combustion, even in an explosive mixture of gas and air, is relatively slow as the chemical combination approaches completion.

Another point proved by Hopkinson's experiments in a large closed vessel is that at whatever point in the vessel the ignition be started, that point is the point of maximum temperature during the subsequent pressure rise, and at that point the temperature rises about 500 degrees above the temperature of combustion, due to adiabatic compression of the hot gas.

The investigations of Profs. Callendar, Dalby, and Coker by means of platinum resistance thermometers and platinum alloy thermal couples has proved the temperatures attained in ordinary engines to vary from about 1,800 deg. Cent. to 2,300 deg. Cent. The new methods of direct thermometric measurement of the temperature flame have amply proved, however, the general correctness of the older method of deducing mean temperature by pressure change.

The investigations of Callendar, Hopkinson, and David on radiation are of great importance, and prove that this source of heat loss is only second in magnitude to heat loss by convection and conduction. All the radiation experiments clearly show the existence of an unexpected transparency of flame to its own radiations. The radiation work throws much light upon heat distribution in the rapidly succeeding explosions used in internal combustion engines.

It was long ago observed by Hirn, Bunsen, and others that the rise of temperature in gaseous explosions could not be calculated from the then assumed specific heat of the constituent gases and the known calorific value of the inflammable gas. The deficit of temperature was found to be about 50 per cent, and many attempts were made to explain this deficit, Hirn advocating the theory of heat loss on the rising line and Bunsen supporting the idea of a limit to temperature due to dissociation. Later, the French observers, Mallard and Le Chatelier, maintained that at least part of the deficit could be accounted for on the assumption of increase of specific heat of the gases. Investigations of the members of the committee have dealt, not only with the points which have been here discussed, but with all these questions—heat loss on the rising line, specific heat of the constituent gases, heat loss on the falling line, and dissociation of the combining gases.

Specific heat work has been in progress by Clerk, by Callendar and his pupil, Swann, and much of this work has not yet been published. Dissociation has been discussed by Dr. J. A. Harker, Prof. Smithells and Dr. Bone, and both internal energy and dissociation have been discussed by Hopkinson. Ignition temperatures of gases have been dealt with by Prof. Harold Dixon, and Dr. Watson has studied the nature of the exhaust gases from the gasoline engine. Many experiments, too, have been made on the law of cooling and heating of gases under compression in cylinders by Hopkinson, Dalby, Callendar, and Clerk.

As a result of this work, the conclusion has been arrived at that, so far as explosions in internal combustion engines are concerned, dissociation has but little to do with the limit reached. This limit is partly due to increased specific heat at high temperatures, to heat loss to the walls, and to radiation from the explosion. Varying specific heat and increasing radiation account for most of the deficit. Allowing for all these things, however, it appears now to be established that combustion is not quite complete even at maximum temperature, and Watson's experiments on the spectrum of an explosion flame appear to support this view.

All these matters are still under examination, and it is hoped that in the near future a much more complete knowledge may be gained than at present exists. Much is known in a qualitative way, and some quantitative knowledge has been attained, but much still remains to be done in the way of quantitative determinations of matters at first apparently so simple as specific heat.

* Abstract of discourse delivered at the Royal Institution on Friday, January 29th, 1915, by Dr. Dugald Clerk, F.R.S. From Nature.

Flashlight Signals on the Boston & Maine

THE Boston & Maine, which has used flashing acetylene lamps on signals experimentally for nearly two years, now has these lamps in use on about ten miles of its line, from Parkway Bridge, Mass., to Reading Highlands, on the Portland division. This is a double track line and there are thirty-six block sections, a home and a distant arm on each post. Both arms have the flashlights, and they flash from 58 to 62 times a minute. The signals at interlockings have ordinary steady lights, so that enginemen are able quickly to distinguish automatic from non-automatic signals.

By an automatic regulator in the pipe supplying gas to the lamp, the gas is made to flow only one tenth of the time, making each lamp glow, for example, one tenth of a second and then remaining dark nine tenths of a second.

The night signals on the Boston & Maine show white for proceed, red for stop, and green for caution.

Steady acetylene lamps have been used on several hundred block signals on the Boston & Maine for several years past.

The Norfolk & Western has had one of the flashlights in use on an automatic signal for the past eight months and reports the lamp as not only very reliable, but as costing much less than an oil lamp for the same service. On both this road and the Boston & Maine the enginemen are reported as much pleased with the flashlight.—*Railway Age Gazette.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, MAY 1st, 1915

Published weekly by Munn & Company, Incorporated

Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

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WE beg to advise our readers that we have discontinued selling numbers of the SCIENTIFIC AMERICAN SUPPLEMENT dated earlier than January 1, 1914. We removed the first week in April to the Woolworth Building, New York city, and the change in our offices precluded the carrying of issues of the SUPPLEMENT extending over a period of nearly forty years. It was, therefore, necessary to turn over this portion of the business to some one who has space for carrying so large a stock. The H. W. Wilson Company of 30 Mamaroneck Avenue, White Plains, N. Y., have been chosen to take care of our back number business. They have the complete stock and are ready to supply any of the back numbers at the standard price of 10 cents. We, therefore, request that, in future, all orders for SUPPLEMENTS be sent direct to the H. W. Wilson Company instead of ourselves. Please do not order SUPPLEMENTS on letters ordering subscriptions for the SCIENTIFIC AMERICAN or the SCIENTIFIC AMERICAN SUPPLEMENT or books, or containing any other matters.

MUNN & CO., INC.,
Publishers of the SCIENTIFIC AMERICAN.

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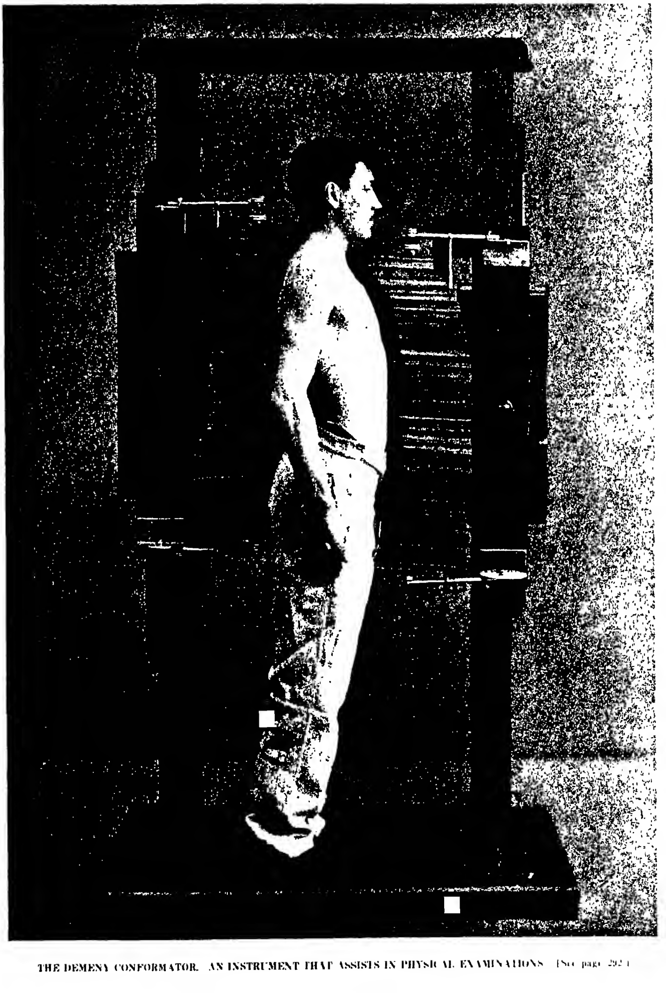
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX
NUMBER 2053

NEW YORK, MAY 8, 1915

10 CENTS A COPY
$5.00 A YEAR



THE DEMENY CONFORMATOR. AN INSTRUMENT THAT ASSISTS IN PHYSICAL EXAMINATIONS. [See page 292.]

Atoms and Ions—II*

A Comprehensive Discussion Especially as Related to Gases

By Sir J. J. Thomson, O.M., F.R.S.

Concluded from Scientific American Supplement No. 2052, Page 274, May 1, 1915

In opening his discourse the speaker said that, on the previous occasion, he had shown that if a discharge-tube were fitted with a fluorite window, the light which traversed this window was capable of endowing air with conductivity. He had also shown that on placing a thin plate of quartz before this window the conductivity of the adjacent air vanished; and, further, that if the air taken for investigation were drawn, not from the immediate surface of the fluorite, as in the original experiment, but from a region a few millimeters away, no conductivity was apparent. This showed that the ionizing rays were wholly absorbed within a depth of 2 millimeters or 3 millimeters of air at normal pressure. The rays in question belonged, he said, to what was known as the Schumann region of the spectrum.

He had himself, Sir Joseph Thomson continued, been working on the radiation produced by Röntgen rays, in which the cathode rays originating them were much slower than usual. He had started with rays of which the energy (measured in a certain way, to be defined later) was represented by a few volts, and had gone up to energies corresponding to 3,000 volts. He had investigated the nature of the Röntgen radiation given out when the type of cathode ray was varied through the range stated. The observations made confirmed in a very remarkable way a view he had put forward three years ago as to the origin of the characteristic radiation. He had then suggested that the emission of characteristic radiation marked the return of a negative particle to an atom which had been previously ionized by being deprived of negative electricity. Every ionized atom, when it re-acquired a negative charge gave out a characteristic radiation, and the energy of this radiation measured the number of atoms ionized by the cathode rays. An atom could be ionized in divers ways by taking a negative particle from different parts of its structure. If the particle were taken from the surface of the atom, not much work would be required to ionize the atom, and when it re-acquired the charge it would correspondingly give out characteristic radiation of a very soft type. If, however, the ionization were affected by removing the negative particle from a point nearer the center of the atom, more work would be required, and when the charge was regained, the characteristic radiation would be of a "hard type." He had found it possible to get in this way a great number of different "characteristic radiations," by gradually increasing the energy of the cathode rays used.

The ultra-violet light which passed through quartz was able, the speaker continued, to make some gases conductive, but not others. Thus Steubing had found that mercury vapor exposed to "quartz" light possessed some small amount of conductivity. This was a very interesting fact, and the question arose as to what were the properties of a gas which determined whether it did or did not become a conductor when exposed to light of a particular wave-length. In the subjoined table, the results recorded in the second line were observed in experiments made by Frank and Hertz to determine the amount of work required to ionize the molecules of different gases; that was to say, the energy needed to separate a corpuscle from an atom. The ionizing energy given in the second line of the table was expressed as a certain number of volts, this number being the voltage through which a unit charge would have to fall to acquire the energy necessary to ionize the atom:

Element	Hg	N	O	H.	Ar.	Ne.	He.
Ionizing energy (volts)	4.9	7.5	9	11	12	16	20.5
λ	2536	1600	1333	1090	1000	750	600

From the table it appeared that, for ionization, mercury required an amount of energy represented by 4.9 volts, nitrogen 7.5 volts, and oxygen 9 volts. The inert gases argon, neon, and helium, in contradiction to what might have been anticipated from the brilliancy of the discharge through them, were more difficult to ionize. Mercury vapor was evidently by far the easiest to ionize of the elements tabulated, but were the table extended to include such electro-positive bodies as sodium and potassium, mercury would be shifted from its position of priority. Underneath the ionizing energy will be found values of λ, where λ denotes that wave-length of that light, which was connected with the ionizing energy immediately above it, by the "quantum law." Light, the lecturer proceeded, behaved in many respects as if it were made up of discrete bundles, each endowed with a definite amount of energy. This amount depended upon the wave-length of the light, the smaller the wave-length the greater being the energy in each bundle. The energy in each bundle was, in fact, proportionate to the number of vibrations made per second by that particular kind of light. The numerical relationship between the ionizing energy (expressed in volts, as already explained) and the wave-length was given by the relation

$$\text{I. V} = \frac{12.2 \times 1000}{\lambda}$$

where λ was expressed in Angstrom units, and it was from this expression that the wave-lengths given in the last line of the table had been calculated. In order, therefore, that light should render a gas conductive, the energy in each "parcel of light" must be equal to the energy required to ionize a particle of gas. Hence light with a wave-length of 2,536 Angstrom units should ionize mercury, and light of this wave-length would pass through quartz. On the other hand, to ionize nitrogen the wave-length must not exceed 1,600, and to light as ultra violet as this quartz was opaque, a wave-length of 1,800 being about as short a wave-length as quartz would pass. Fluorite, on the other hand, was transparent to light of as short a wave-length as 1,200 Angstrom units, and hence it was to be expected that oxygen and nitrogen might be ionized by light able to traverse fluorite. This light would not, however, ionize hydrogen, which required the wave-length to be less than 1,090, to which fluorite was opaque. It would be seen that these conclusions corresponded very well with the results of experiment, air being ionized by "fluorite ultra-violet," and mercury by "quartz ultra-violet," while the others were immune to both.

There was, however, more in it than this, for in the mercury spectrum the wave-length 2,536 corresponded to one of the most brilliant and important lines, and, as stated, 2,536 was the wave-length corresponding to the ionizing potential. In some recent experiments by Frank, in which mercury was ionized by cathode rays sent through different definite falls of potential, he found that the spectrum of the mercury showed no trace of the line at 2,536 wave-length so long as the fall of potential was 4.9 volts or under; but that when this fall was increased to 5 volts or a little more, the line began to make its appearance, and increased in intensity as the voltage fall was still further augmented. The appearance of this line in the mercury spectrum coincided, in short, with the use of cathode rays having the critical amount of energy. Ionization was therefore closely connected with radiation, and by measurement of the energy required for ionization it was possible to deduce the position of conspicuous lines in spectra.

Perhaps the most famous case of ionization produced by light capable of passing through quartz was that discovered by Stark, who found that anthracene vapor became conductive when exposed to "quartz ultra-violet" light. The effect could be clearly shown by submitting anthracene vapor, inclosed in a quartz vessel, to the light of a mercury lamp having a quartz bulb. In that case, an electroscope coupled up to one of two electrodes (the other being earthed) immersed in the vapor gave evidence of a distinct leak. This experiment however gave rise to certain difficulties of a theoretical character. It was believed that conductivity was an atomic phenomenon, and did not depend in any way on what companions were associated with a particular atom, the ionizing potential being quite independent of these. The light which passed through quartz had a wave-length of, say, 2,000 Angstrom units, and, so far as is at present known, the only gas which could be ionized by light of this wave-length was mercury vapor. It was true that no figures existed for carbon, but no other hydrocarbon than anthracene was ionized by "quartz light," and it was thus difficult to understand why anthracene should be.

For his own part he was not convinced that the ionization found in the case of anthracene did not arise from quite a different cause than from the direct action of the light as exemplified in the ionization of air by the "fluorite" rays. In the last lecture he had shown that when "quartz light" fell on metals, the latter gave out negative electricity. It seemed possible that when exposed to ultra-violet light anthracene might polymerize fine dust being produced as one result of the change, and that this dust, when exposed to the action of ultra-violet light, might give out negative electricity, just as small particles of metal would do in the same circumstances. If this were so, the apparent conductivity of anthracene vapor would be due to the photo-electric effect of light on solid particles. The accuracy of this hypothesis might, perhaps, be tested by measuring the speed of the particle in an electric field; since, when a dust particle acted as an ion, its speed was only 1/1000 that of the positive particles produced in genuine ionization. Tyndall indeed had shown that by the action of light on certain vapors, clouds of small particles were produced, and if anything analogous to this took place with anthracene, we should have an explanation of its conductivity which would not conflict with views held to be well founded from other considerations.

The lecturer next considered quite a different method of making a gas conductive, the ionization being produced by splashing or bubbling. The pioneer experiments in this line had been made by Faraday, who had carried out a very remarkable research on the electricity produced when steam was forced through narrow passages, as in Lord Armstrong's hydro-electric machine. Next after Faraday came Lenard, who was led to the subject by the attempt to find some explanation of a long-known fact—viz., that the air at the foot of a waterfall was in a somewhat anomalous condition, many observations having shown such air to be very peculiar. Lenard found that a considerable amount of ionization arose whenever water fell and struck a solid obstacle. The ions thus produced were of a type rare in "ionic populations," where, in general, there was no middle class. Big ions were found in plenty moving with a velocity corresponding to a fall of 1 volt per centimeter, and also many small ions moving at a speed 1,000 time as great. There was, however, a lack of ions to fill up the intermediate gap, but the ions observed near the foot of a waterfall had this intermediate character.

Their production was extraordinarily susceptible to slight impurities in the water. With ordinary tap-water no ionization was produced by splashing, and till the importance of using extremely pure water was realized, Lenard found himself unable to repeat in Bonn observations made at Heidelberg, where the water supply was purer. The speaker had himself found it possible to detect by their effect on the ionization produced by splashing, the presence in water of traces of rosaniline, which could not be detected by the coloration produced. Further, if sulphuric acid were added to the water in small quantities, no ionization was produced by splashing; while if more acids were added, so as to get a stronger solution, ionization was again observed, but its sign was reversed from negative to positive. An addition of 1 part of acid to 2,000 of water was sufficient to effect this change of sign.

Splashing was, he continued, very analogous to bubbling. Lord Kelvin was the first to observe the negative electrification produced when air was bubbled through water. The phenomenon was, however, to be observed only with certain liquids, gasoline, for example, giving no ionization. In fact, liquids were divisible into two sharply separated classes, according as they did, or did not, show electrification by splashing or bubbling. The division was one which ran through a considerable number of properties. Some, such as water, the alcohols, and phenols, had a large surface tension, and an abnormal specific inductive capacity, this being much larger than calculated from Maxwell's law, according to which the specific inductive capacity should be equal to the square of the refractive index. This property these abnormal bodies retained even in the gaseous state, the specific inductive capacity of water and alcohol being enormous in comparison with the squares of their refractive indices.

He had himself suggested that the two classes of compounds differed, in that with those having an abnormal specific conductive capacity, the atoms of the molecule were oppositely charged with electricity, while in normal bodies the atoms of the molecule were individually neutral. It was only with the abnormal liquids that ionization occurred on splashing, none being found with the normal class.

The ionization produced by bubbling had an important bearing on another thorny question—viz., that of ionization by chemical action. When hydrogen was produced by the action of dilute acid on zinc, the reaction was necessarily accompanied by the bubbling of the gas through the liquid reagents. Many chemical actions were, in fact, accompanied by large amounts of electrification, and it was a question whether this was genuine ionization by the chemical action or merely splashing.

* Reproduced from *Engineering*

aspect of ionization by bubbling. A large effect due to the latter cause was to be expected, as the bubbles were very small. It could not, indeed, be doubted that in a large number of cases it was this bubbling that was accountable for the whole of the electrification observed.

There were, however, other cases to which this explanation would not apply. One of these (still without any very thorough explanation) was the ionization produced when air was drawn over phosphorus. If a little phosphorus were placed in a tube through which air was sucked, then, if a collector in the tube were connected up to an electroscope, the latter indicated that the air which had passed over the phosphorus had become conductive. This might seem as simple a case of chemical action as we could have, but Bloch had shown that the matter was really rather complicated. The passage of the air over the phosphorus was accompanied by a faint luminosity, and by increasing the speed of the air current this luminous cloud could be drawn clear of the phosphorus, leaving a dark space between. Bloch found that if his collecting wire were placed in this dark space, there were no signs of conductivity; while if placed in the luminous cloud, there was conductivity. This green phosphorescent cloud was attributed to the further oxidation of a highly unstable oxide (P_2O_3) first formed.

This appeared to be a comparatively simple case of chemical action accompanied by conductivity, but there was, nevertheless, something exceptional about it, since similar chemical and light effects were to be observed with sulphur and arsenic, a similar luminosity and similar unstable oxide being formed, but without any trace of conductivity. There were, in fact, corresponding chemical and optical effects, but no ionization. This instance well illustrated the difficulties met with in connection with the question of ionization by chemical action. He had shown in the last lecture that hot solids gave out electricity. Many chemical reactions were accompanied by the formation of solids, which, if hot, would give out negative charges; but the ionization thus produced was not that of theoretical importance, and it was very difficult in the case of chemical reactions to separate these spurious types from the true. As matters stood, it would be premature to say whether or no ionization was ever directly produced by chemical action.

(To be continued.)

The Scientific Work of Prof. J. C. Bose

By Jakob Kunz, Ph.D.

In the realm of natural science we find three fundamental achievements of the human mind, three victories over the material world which has yielded to the searchlight of human thought three of her great secrets. The first great synthesis was that of Newton, who found in the law of gravity a common property of all ponderable matter and thus laid the theoretical foundations for mechanics and astronomy. A second great synthesis was carried out by Faraday-Maxwell, who came to the conclusion that light is an electro-magnetic phenomenon, that in a beam of light there are acting the same forces as operate between two electrified spheres and between magnets. If we observe the attractions and repulsions between electric charges and between magnets, the magnetic action of electric currents, the forces acting in dynamos, motors and transformers, and if we consider the large variety of phenomenon of light—the reflection, refraction, polarization, double refraction, rotation of the plane of polarization, and interference and diffraction of light with their wonderful color effects—we would hardly suspect a bond of unity to exist in all these phenomena. Nevertheless science has discovered the common bond of unity of all electro-magnetic phenomena. This scientific synthesis lead to the discovery of electric waves by H. Hertz, which are used specially in wireless telegraphy.

The third wide synthesis is that of Charles Darwin, who came to the conclusion that all living beings, plants, animals and men are connected with each other through a process of evolution and that they arose from the same source. There are other great triumphs of the human intelligence over the material world, as for instance in the organic and inorganic chemistry, and in other fields, but no other synthesis has been so general and far reaching as those mentioned. Prof. J. C. Bose's work is intimately connected with the last two synthesis; namely, the electro-magnetic nature of light, and the unity of all life on the surface of the earth. The electric waves predicted with all their properties by Maxwell, were discovered by H. Hertz in 1887. These waves about three meters long showed reflection, refraction and polarization like a beam of light. But they were still about ten million times longer than the beam of visible light. Prof. Bose has thrown a bridge over the gulf by creating and studying electric waves of about 6 millimeters, the longest heat and light waves known at the present time being about 0.6 millimeters. There still exists a very small gap, but there is no doubt that waves of the same wave length produced by electrical methods and by heat and light radiators will be absolutely identical. Prof. Bose showed that these short electric waves have the same property as a beam of light, exhibiting reflection refraction, even total reflection; through a black crystal, double refraction polarization and rotation of the plane of polarization. The thinnest film of air is sufficient to produce total reflection of visible light with its extremely short wave lengths. But with the new electric waves which he discovered, Bose showed that the critical thickness of the air-space was determined by the refracting power of the prism and by the wave length of the electric oscillations. He found a special crystal, Nemalite, which exhibits the polarization of electric waves in the very same way as a beam of light is polarized by a Tourmaline crystal. The rotation of the plane of polarization was demonstrated by Prof. Bose by means of a contrivance twisted like a rope and the rotation could be produced to the left or to the right, just as different sorts of sugar rotate the plane of polarization of ordinary light to the right or to the left. Prof. Bose determined the index of refraction for his electric waves for different materials, and eliminated a difficulty which presented itself in Maxwell's theory as to the relation between the index of refraction of light and the dielectric constant of insulators. He measured also the wave length of various oscillations; to detect them and study their various properties, he had to construct a large number of new apparatus and instruments, and he has [illegible] by a number of apparatus distinguished by simplicity, [illegible] and [illegible]. It was a hard task to produce very short electric waves which had enough energy to be detected, but Bose overcame this great difficulty by constructing radiators or oscillators of his own type, which emitted shortest waves with a sufficient amount of energy. As a receiver he used a sensitive metallic coherer, which in itself led to new and important discoveries. When electric waves fall on a loose contact between two pieces of metals, the resistance of the contact changes and a current passes through the contact indicating the existence of electric oscillations. Prof. Bose discovered the surprising fact that with potassium metal the resistance of the contact increases under the action of electric waves, and that this contact exhibits an automatic recovery. He found further that the change of the metallic contact resistance when acted on by electrical waves, is a function of the atomic weight. These phenomena led to a new theory of metallic coherers. Before these discoveries it was assumed that the particles of two metallic pieces in contact are, as it were, fused together, so that the resistance decreases. But the increasing resistance, appearing for some elements, leads to the theory that the electric forces in the waves produce a peculiar molecular action or a rearrangement of the molecules, which may either increase or decrease the contact resistance. Self-recovery and fatigue of these coherers reminds us of the phenomena of living organisms. Here we find indeed the natural bridge between the two fields of the scientific investigations of Prof. Bose, between physics and physiology.

With the advance of the various sciences it became more and more difficult for a single investigator to make contributions to different field of knowledge. The special theories and the methods of each science increase every year and the definitions of the concepts are so different that a scientific man rarely finds himself at home in a science outside his own field. Prof. Bose is one of the rare exceptions. As in physics, we find his investigations in the physiology of plants and animals clustered round one fundamental idea, the idea of the unity of all that lives. Again, as in physics, Prof. Bose made contributions to physiology by the construction of new instruments of investigations characterized by marvelous simplicity, ingenuity and sensitiveness. I will mention among a large variety one, the Resonant Recorder, in which the friction of the writing pen has been eliminated by means of the principle of resonance and which allows the measurement of time intervals as small as a thousandth part of a second. Bose also discovered a series of new phenomena and offered new interpretations.

In physics and chemistry the law of the uniformity of nature may be stated as follows:

Under the same conditions a given cause produces always the same effect.

In physiology Prof. Bose would probably express the same law in somewhat different terms as follows:

Under the same conditions a given stimulus produces in the plant and animal the same well defined response. Of course it is much more difficult to re-establish the same conditions in the living than in the non-living world. With increasing intensity of stimulus the response increases; at very high intensities of the stimulus, however, the response reaches a limit. Stimuli too small to produce a visible effect, if applied singly, become effective by superimposition. If the intensity of successive stimuli is kept constant it may still happen that the height of the corresponding responses gradually increases as if the molecules adapted themselves more and more to the external influences; this is the staircase effect, so well known in the cardiac muscle but also discovered by Bose in plants. Not only the intensity, but the frequency of stimulus affects the response. Fatigue and recovery play an important part in the response of plants to external influences, and these effects have been recorded by Prof. Bose's instruments with the same fidelity as purely physical phenomena. The influence of temperature, light drugs and poisons on vegetable and animal tissues have been studied and recorded. Plant and animal exhibit the same function of life on closer scientific investigation.

Let us illustrate this result by a few examples chosen at random from Prof. Bose's very rich scientific treasury. Let us ask, does the plant sleep? Is the plant equally sensitive to external stimuli during day and night? This problem was solved by new apparatus which delivers a questioning shock to the *Mimosa* plant every hour of the day and night, and which records automatically the response. The record obtained shows that the plant wakes up during the morning very slowly, becomes fully alert by noon, remaining so until evening, and becomes sleepy only after midnight, resembling the modern man in a surprising manner.

Electrical methods have been found more effective in the investigations of the functions of the plant than mechanical methods. Indeed mechanical movements in the plants are rather exceptional, while the animal enjoys the freedom of motion. There are even motions in the organs of animals like the beating of the heart, which seems to take place automatically, apparently without stimulus. These rhythmic automatic motions, these throbbings, however, occur in the plants also, for instance, in the oscillating leaflets of the telegraph plant. Temperature variations, anaesthetics, poisonous acids and bases have the same effects on the throbbing heart and the oscillating leaf. Moreover, in the plant-life it is possible to trace the evolution from simple to multiple and to automatic response.

A difficult problem arises in connection with the transmission of impulses through plant organs which resembles in many respects the transmission of excitation through nerves. The transmission of the impulse from the surrounding world follows the same laws in the body of the plant and of the animal.

There are other problems connected with the control of the nervous impulse at will, and with the existence of memory. The researches of Bose have proved that there is no physical property of matter exhibited in the living world which is not manifested also in the inorganic world. Indeed the investigations of Bose have shown not only a continuity of reactions between plants and animals but also the oneness of matter and its properties in the living creatures and in non-living matter. We admire the human eye as one of the finest products of the creative power of nature, yet Prof. Bose was able by purely chemical means and physical forces to discover a photo-electric cell, an artificial eye, which shows essentially the same relations between stimulus and response as the human eye. Incidentally, he discovered the surprising fact of a binocular alternation of vision in man.

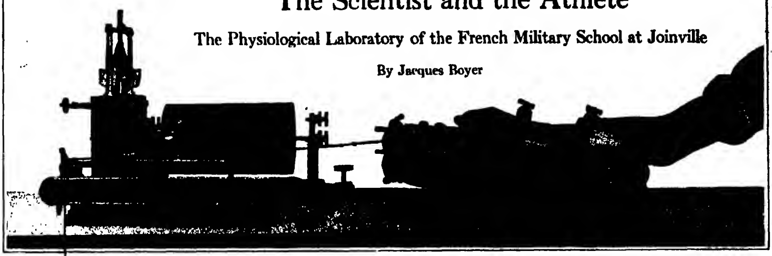
The uniformity of responses by animals, plants and metals are recorded by diagrams so identical that one could not tell which belongs to the animal kingdom or to the plant, or to the dead metal. The laws of nature hold uniformly throughout the whole material world. Thus Nature is a universe, a cosmos, whose secret laws the human mind is able to decipher.

Interesting accounts are to hand from Sweden regarding the results of trials lately conducted by a leading Swedish company on two sister steamers, one—the "Mjölner"—being fitted with turbo-electrical engines and the other—the "Mimer"—with ordinary triple-expansion engines. Each steamer is of 2,225 tons displacement and designed for a speed of 11 knots, a stipulation being that in each case the engines were to develop 900 indicated horse-power. The most important factor, however, was with regard to the consumption of coal, which was guaranteed to be 30 per cent less in the turbo-electrical vessel than in that fitted with the triple-expansion engines. For the trial trip, which lasted 7 hours, the screws of the "Mimer" were fitted to the "Mjölner," so as to avoid possible difference arising from any difference in construction. During the trip the turbo-electrical engine developed 975 indicated horse-power, or 75 more than the guaranteed maximum, while the average speed was 11.8 knots, as against 11 guaranteed. Good as these results are, the small consumption of coal exceeded the most sanguine expectations, amounting to 0.4 kilogramme per indicated horse-power, which works out at 35 per cent less than the consumption on the sister ship, the "Mimer." Both steamers are to be employed in the coast trade and their hulls have been especially constructed for navigation in the ice.

The Scientist and the Athlete

The Physiological Laboratory of the French Military School at Joinville

By Jacques Boyer



The Mosso ergograph, which registers the work done by the fingers.

At the normal fencing and gymnastic school which the French war ministry maintains at Joinville, systematic physical training is given to officers and men, and methods of improving the physical condition of the men of the auxiliary service are investigated. Especial attention is given to perfecting the exercises and methods of training, with the aid of scientific researches carried on in the physiological laboratory of the school. In addition to the recording instruments which are commonly employed by physiologists and psychologists for the study of respiration, circulation, and muscular contraction, the laboratory contains several novel and interesting instruments invented by Prof. G. Demeny for the determination of the form and dimensions of the body at rest and in movement. The laboratory is also well equipped for work in photography, including chrono-photography and kinematography.

The dimensions of the thoracic cavity are measured with calipers having blunt tips of ivory. One of these tips is affixed directly to one leg of the instrument, but the other tip is attached to a rod which can move in a graduated slide against the pressure of a spring. This construction allows the calipers to be withdrawn without opening them or wounding the subject. When the instrument is applied to the chest the spring tip remains in contact with the body without interfering with respiration, so that the travel of the rod measures the augmentation of the thoracic diameter in the act of inspiration. By connecting the rod with a pair of Marey capsules, a continuous record of the variations in diameter can be inscribed on a rotating cylinder.

In order to obtain more precise measurements of all dimensions of the body, Prof. Demeny has devised an instrument, the double universal conformator, which can be adjusted to trace on paper outlines of the median vertical section of the trunk, and of horizontal sections at various heights. The essential organ of this apparatus is a metal rod, to which numerous thin strips of wood, forming a continuous series, are attached transversely in such a manner that each strip can move independently in a direction parallel to its length (or at right angles to the rod) and that all the strips can be fixed in position by turning a nut at the end of the rod. The ends of all the wooden strips are brought into contact with the body, and the nut is screwed down. The contour of the body can be traced on paper from the profile of the strips thus immobilized.

With two such rods, mounted parallel to each other on suitable supports, the form of horizontal sections of the body, or of its lateral or anterior and posterior vertical profiles can be determined very quickly. Complete horizontal sections of the chest at various levels are obtained by attaching four rods to a rectangular frame, inside which the man stands on a platform which can be raised to any desired height.

The Demeny conformator reveals immediately and without calculation any defect of symmetry, such as unequal height of shoulders or hips, abnormal curvature of the spine, etc.

For the special study of the spine an instrument called a rachigraph or profilograph has been devised. Four rods, connected by movable joints to form a rhomb, are supported by a carriage that moves in a slot in a vertical post. The subject stands with his back to the post, and the carriage is moved upward, while a blunt point attached to one vertex of the rhomb is pressed against his spine. Simultaneously, a pencil attached to the opposite vertex of the rhomb traces the profile of the spine, in its true dimensions, on a sheet of paper.

Vertical sections are obtained also by an instrument which traces the profile on paper by means of pencils attached to two rods, mounted on rollers, between which the subject is placed, and which measure the thickness of the body at every point as they move up or down.

The volume of air introduced into the lungs by a deep inspiration is measured by a very simple spirometer. The inhaled air is expelled through a rubber tube into a cylindrical bell-glass, which dips into water contained in a larger glass vessel. The cross-section of the tube is made equal to that of the trachea in order to minimize resistance and disturbance of the rhythm of respiration. The bell-glass is suspended by a cord which passes over two pulleys and has a counterpoise attached to its other end. The bell-glass rises as the air is blown into it, and if its wall were infinitely thin its rise, indicated by the emergence of an attached scale from the water, would be exactly proportional to the volume of air introduced, the pressure remaining constant. In practice, however, there is a small increase of pressure, which is measured by a manometer inside the bell-glass and is applied as a correction. The spirometer is calibrated by injecting air in measured quantities, one liter at a time, and reading both the water level scale and the manometer after each addition.

Many of the physiological researches that are conducted in this military school are executed by Marey's method, which is capable of furnishing graphic records of respiratory movements, the pulsations of the heart and the arteries, muscular contractions, the pressure of the feet on the ground in walking, leaping, etc. The part of the body which is being examined is brought into contact with the flexible membrane of a Marey capsule, which is connected by a rubber tube to a similar capsule, whose membrane carries a stylus that presses on a cylinder covered with blackened paper and turned uniformly by clockwork.

The variations of muscular effort are registered by the well-known ergograph of Mosso.

The mechanism of bodily movements is studied also by means of photography, kinematography, and, especially, chrono-photography. The kinematographic analysis of movements enables the physical instructor to discover the physiological consequences of various exercises, and to classify the latter according to their effects, but he must control his deductions by attentive observation of the movements.

Chrono-photography may be defined as the photographic reproduction of successive positions of a moving object on a single fixed plate. Graphic chrono-photography is based on the same principle, but it furnishes a much larger number of images in a given time. The pictures of this sort that are produced at the Joinville school are exceedingly interesting, and convey very valuable information in regard to walking, high and broad jumping, and other exercises. So, at Joinville, physiologists and trainers work together for the improvement of physical education.

The Sterilization of Water-Supplies for Troops on Active Service*

By G. Sims Woodhead, M.D.

Some years ago, while working at the sterilization of the Cambridge water supply, I found that it was not necessary to make a bacteriological examination in order to determine whether the bacillus coli group had been killed by the addition of certain quantities of bleaching powder (chloride of lime) to the water under observation. Working with very dilute solutions of bleaching powder I found that the amount of "available" chlorine required to be added to the Cambridge water to "sterilize" it was frequently only about 1 part in 7,000,000. In such cases the number of bacteria present was very small and the amount of organic matter very low, and I found, even after the addition of the above small quantity, that if, a quarter of an hour after the addition of the chloride of lime, I obtained a blue or a violet-blue reaction with iodide of potassium and starch, as much as a liter and a half or even two liters of the treated water did not contain a single "living" bacillus coli communis. In some earlier experiments I was able to demonstrate that the typhoid and cholera bacilli were perhaps even less resistant to the action of hypochlorous acid than was the bacillus coli communis.

Carrying out a further series of experiments, I satisfied myself that if the particulate matter could be removed from a water by means of any of the ordinary filters it was possible to render even a highly polluted water perfectly safe for drinking purposes by the addition of appropriate amounts of chlorine, and that these appropriate amounts could be determined by means of the iodine and starch test.

The following is a method of testing and sterilizing water for the information of those in charge of the water-cart tanks supplying troops on active service.

All water except that from public tap-water (potable) supplies must be regarded as dangerous and unfit for drinking.

Filter through the best rough filter available, e. g., army service filter, improvised sand filter, etc.

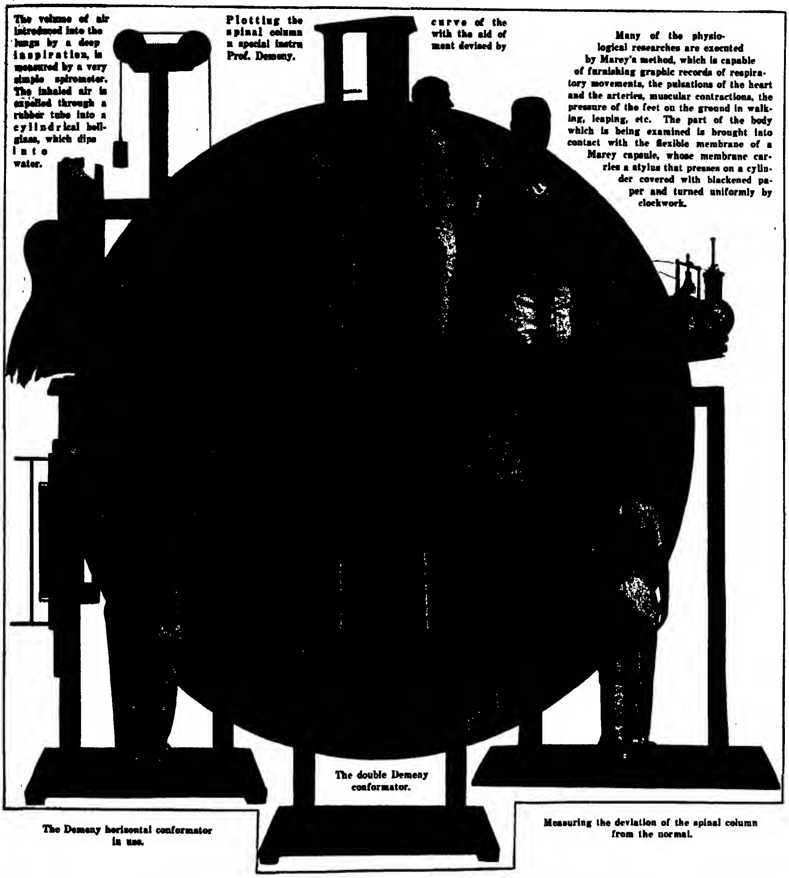
Pollution in water may be detected and the water rendered safe for drinking by the following method:

TEST BEFORE TREATMENT IN BULK.

Instructions I.—Rinse a clean enameled iron or earthenware pint mug with the water to be tested, leaving a few drops in the vessel. Add 2 grammes of bleaching powder (chloride of lime, chloro-hypochlorite of lime) and make into a thin paste, rubbing it down with a clean stylographic pen, penholder, pencil, or glass or other similar clean rod available. Then add 500 cubic centimeters or 18 ounces of water (i. e., fill to within ¾ inch of the lip of the enameled mug or ⅝ inch of the lip of an earthenware mug) and mix thoroughly by pouring into a second mug and then back into 1. The quantities indicated below of the resulting solution may be used for testing purposes; the remainder is used for sterilizing the water. This solution should contain 0.66 gramme of available chlorine.

Instructions II.—Now fill four pint mugs to within ½ inch of the top with the water to be tested. Then allow the bleaching powder solution to rise in a pipette graduated to contain 0.15 cubic centimeter to the mark; wipe the outside of the pipette and blow the contents into one of the four mugs of water to be tested. Add two similar charges of the pipette to a second of these mugs, three charges to a third, and four charges to a fourth, in each case mixing thoroughly (as under Instructions I), and allow to stand for 15 minutes. Then into another clean mug crumble a small tablet of iodide of potassium; also after powdering, in the corner of an envelope or between a couple of layers of clean paper, a tablet of soluble or boiled starch, and pour into it the water from 3, and mix by pouring backward and forward from one vessel to the other. Add iodide of potassium and starch to cups 4, 5, and 6, treating in the same way. When a blue color appears in any of these mixtures it is an indication that the chlorine has not all been used up in that mixture; what remains sets iodine free from the iodide of potassium, which acting on the starch gives a blue color, i. e., more available

* From the *Lancet*.



The volume of air introduced into the lungs by a deep inspiration, is measured by a very simple spirometer. The inhaled air is expelled through a rubber tube into a cylindrical bell-glass, which dips into water.

Plotting the spinal column curve of the with the aid of a special instru ment devised by Prof. Demeny.

Many of the physiological researches are executed by Marey's method, which is capable of furnishing graphic records of respiratory movements, the pulsations of the heart and the arteries, muscular contractions, the pressure of the feet on the ground in walking, leaping, etc. The part of the body which is being examined is brought into contact with the flexible membrane of a Marey capsule, whose membrane carries a stylus that presses on a cylinder covered with blackened paper and turned uniformly by clockwork.

The double Demeny conformator.

The Demeny horizontal conformator in use.

Measuring the deviation of the spinal column from the normal.

chlorine than was necessary to carry oxygen to the organic matter and less resistant organisms has been added, and the water treated in bulk as under Instructions III, is rendered "safe." To free the water from the bacillus coli communis and from non-spore-bearing pathogenetic water-borne organisms it is not necessary to add more bleaching powder than is indicated as required by the test.

Instructions III: Sterilization of the Water.—Should No. 3 give a blue, violet, or brown color (best seen by daylight) the contents of cup 1 may be divided into two equal parts, each of which is sufficient to sterilise 110-120 gallons of water. Distribute this amount, pouring equal quantities into each of the four divisions of the service tank when it is about half filled, and when filled allow to stand for 20 minutes. The water may then be used for drinking without filtration or further treatment. Should No. 3 give no color, but No. 4 become blue, add the whole of the contents of No. 1 to 110-120 gallons, distributing in the same way and rinsing the mug several times so as to wash into the tank the whole of the bleaching powder. Should No. 4 give no color, but No. 5 become blue, dissolve a second sterilising powder "A" (2 grammes of bleaching powder) and add half of it along with the contents of No. 1 to the 110-120 gallon tank. Should No. 5 give no color, but No. 6 become blue, add the whole of the contents of the two tubes "A" to 110-120 gallons. In each case allow the water to stand for 20 minutes before issuing it for drinking. Should No. 6 give no color the water should be regarded as highly polluted, and as palatability is a matter of some importance it should be boiled. By the addition of more bleaching powder, however, up to 6 or 8 grammes per 110-120 gallons it may be rendered innocuous, though in some such cases it may be less palatable.

N. B. (1) The great advantage of this method is that it is not necessary to await the result of a bacteriological examination. The amount of bleaching powder required to render the water safe for drinking purposes may be determined in 20 minutes. Where a new or a variable water has to be used, this is a matter of prime importance.

(2) Other advantages are that with the exception of the pipette no special apparatus is required, and that as the same solution is used for both testing and sterilising any fall in the available chlorine content of the sterilising powder is equalised by a similar fall in the test solution, and the need for the addition of more sterilising powder at once indicated.

(3) If for any reason the supply of standard sterilising tubes should fail it will be found that three times as much fresh, clean, dry, loose bleaching powder (which should contain 33 per cent of available chlorine) as can be lifted on a sixpenny piece grasped between the thumb nail and the tip of the first finger and used as a spoon weighs 2 grammes and corresponds to the amount contained in one of the standard sterilizing tubes.

(4) A rough test of the condition of the water to which bleaching powder has been added may be made by taking a cupful of water from the tank 15 minutes after the addition of the sterilising powder, dissolving in it one each of the tablets "B" and "C" (starch and KI) and mixing thoroughly. Should no color appear add another charge to the tank, and again apply the rough test.

(5) A treated water to be "safe" should, at the end of 15 minutes, always give a blue "reaction" on the addition of the tablets "B" and "C."

This method may also be used for the testing and sterilization of the water-supplies of small communities.

Gas and Steam Engines and the Turbine*

Cost of Operation, Investment and Depreciation at Blast Furnaces and Steel Works

By J. E. Johnson, Jr.

UNTIL within a few years only one type of prime mover was used at blast furnaces, steel works and rolling mills—the steam engine, but within that time the steam turbine and the gas engine have forged ahead at a tremendous pace. For a while they threatened the steam engine with extinction, as the turbine could get along with half and the gas engine with a third of the heat consumption required for fairly good engines a few years ago. There is no doubt that the steam practice at steel works and blast furnaces, particularly the latter, a few years ago was almost as bad as could be. In spite of the fact that 10 per cent of the gas is sufficient to blow the furnace with good practice, the whole 50 per cent not used by stoves and auxiliaries was frequently insufficient and coal had to be burnt under the boilers to help out. This condition persists even yet at many plants.

This was the condition with which the gas engine and turbine builders made comparisons and of course the showing was a bad one for the old steam engine. After a while the steam engine builders and the operators of the plants began to see that there were great possibilities in the use of that prime mover which they had neglected. One of the conditions indispensable for best economy with the turbine is superheat. This has long been known as very beneficial to the steam engine, still no one took the trouble to develop the practice for that purpose. But after it had been developed for the turbine it was applied in earnest to the steam engine. The same thing applied to condensing practice in a less degree. The turbine is simply lost without high vacua, far higher than had ever been considered for the steam engine, and new types of condensers were developed for it, but this development showed up in high relief the absurdity of running reciprocating engines non-condensing, and the improved condensers were applied to them, with the result that no large engine plant built with regard for economy is now ever designed to run non-condensing though that practice was standard in the iron and steel business twenty years ago.

With these improvements have gone a rapid increase in boiler pressure and a general overhauling of designs, so that large steam engines can still compete on the heat economy basis with turbines of equal size. On the other hand what is large for an engine is rapidly coming to be small for a turbine. The largest power engines ever built were double compound horizontal-verticals with four cylinders which were of 8,000 horsepower each. There were five of these in one station. A few months ago a single steam turbine was installed in that station, started up and put into the line. Then one after the other the five engines were shut down and the load of each in turn thrown on the turbine.

In electric power development the turbine has three vast advantages over the steam engine, which for large powers have enabled it to outclass the latter utterly, so that the steam engine is no longer considered for such service. The first is that the pressure of steam is converted directly into rotary motion immediately available for driving generators, whereas in the steam engine the pressure must first be converted into a reciprocating motion and that transformed through an expensive mechanism into rotary. In the second place the refinement of the engine has led to increasing complexity, and many moving parts with various motions, whereas the turbine has in effect a single moving part with the simplest possible motion, a uniform speed of rotation. This vastly reduces the supervision and upkeep of the latter as compared with the former. Third, the speed of rotation of the engine is limited by the motion of the parts to about 100 revolutions per minute in large sizes, which necessitate large and very expensive generators for direct connection to it, whereas the speed of the turbine is from 1,000 to 3,000 revolutions per minute and the corresponding generators are very much cheaper.

When we come to blowing engines, we find the relative positions of these two motors to some extent reversed. There are two systems for compressing air, the time honored one with cylinder, piston and valves which operates by direct pressure, and the multiple fan system of imparting a tremendous velocity to the air by a rapidly revolving runner and transforming this velocity into pressure by driving it through a converging nozzle. The velocity and pressure which we can obtain at one operation are limited, but by putting several such fans in series we can obtain any pressure we wish. The operation is the exact opposite of that of the turbine with the difference that where the conversion of pressure into velocity on which the turbine operates can be carried on with very high efficiency (above 95 per cent), the converse operation of converting velocity into pressure can only be carried on with an efficiency of about 70 per cent.

On the other hand, the over-all efficiency of the direct connected reciprocating blowing engine is extremely high—between 85 and 90 per cent in good practice—so that the best designed reciprocating steam blowers under the same conditions as the turbine driven blower have a considerable advantage over the latter in steam consumption. On the other hand, the steam engine costs a little more to install than the turbo-blower, against which we may set the fact that owing to its lower steam consumption it requires less expenditure for boilers.

Great advantages are claimed for the turbo-blower for its smooth and non-pulsating discharge; on the other hand, this is claimed by others to be a positive disadvantage. The metering action of the positive piston compressor is believed by many to be a very great advantage, while on the other hand this action is claimed by the advocates of the turbo-blower not to be nearly as accurate as the volume control of their machine. You will see, therefore, that this is an extremely live question at the present time, and in some company it is scarcely safe to make a positive statement on either side without first putting on a suit of armor.

For driving rolling mills the conditions are different from either of the others. The largest mills handling the huge ingots in their original shape are known as "blooming mills" and these, for reasons for which we need not stop to consider here, generally have to run in both directions to drive the piece back and forth through the rolls; and as these mills are geared directly to the engine it must be of the reversing type. Here the steam engine takes the first position, with no second, since it is the only prime mover which can be reversed at all, let alone at intervals of literally a second or two.

Some of these engines are triumphs of the engine builder's art and are among the most powerful built, having two pairs of tandem cylinders 46 inches and 76 inches in diameter by 60-inch stroke, running condensing with a steam pressure of 150 pounds and up to 175 revolutions. These are reversed from full speed in one direction to full speed in another in three or four seconds, in spite of the vast weight of their reciprocating parts. The shocks are such as no machine should be called on to stand, but they do it and so far no way has been developed to meet some conditions as well as this type of mill and engine, though I have hopes. For non-reversing mills direct geared turbines and gas engines have occasionally been applied, but in the vast majority of cases steam engines are used or else electric motors.

The double transformation of energy involved in the electric drive is expensive in fuel cost and what is much more important it is very expensive in first cost, and it is rather surprising that more has not been done in the designing of non-reversing mills direct geared to the gas engine, and especially to the steam turbine, since the latter has a high efficiency through a wide range of loads, or, as we say, a flat steam consumption curve, which is very important in highly intermittent work like that of rolling mills. I believe that a considerable development will take place in this field in the not distant future.

This motor, as you well know, works on a totally different principle from either of the others and has consequently very different characteristics. It is not capable of much change in speed and its economy drops very rapidly as the load falls off, largely because the friction of the engine is very high and is almost constant, irrespective of the load, so that a friction of 20 per cent at full load means one of 40 per cent at half load, and so on.

This type of engine is also capable of carrying only very slight overloads; that is to say, its most economical load is its maximum load, and any overload capacity is secured only at the expense of economy and at the price of buying a larger engine. In these respects it is at a great disadvantage as compared with either the steam engine or the turbine, both of which have a large overload capacity which extends far beyond their most economical load. On the other hand, the gas engine cuts out entirely the boiler, and above all it has a heat consumption only about two-thirds or three fourths of that of the best steam plants.

It was at one time supposed that this fact was destined to make the gas engine the preferred prime mover for all electric power work; but other considerations came in and this expectation has not been realized, and some of the best gas engine men admit that where coal is the fuel used its day of realization has been indefinitely deferred.

Leaving out of consideration altogether the question of first cost and capital charges for the present, let us consider only the operation. Before coal can be used for gas engines it must be gasified in a gas producer, an apparatus having an efficiency when delivering cold gas (which a gas engine must have) of 75 to 80 per cent, which is almost the same as that of a well designed and operated boiler plant. On that basis the two are even; but while coal may be burnt under boilers for a few cents a ton, say 15 cents, in large plants, it cannot be gasified for much less than 45 cents and often 50 cents.

Now, the efficiencies of the producer and the boiler being almost the same, the fuel consumed will be in the same rate as the heat consumption of the two motors themselves; say, as a liberal figure, 14,000 British thermal units for the turbine and 12,000 for the gas engine, a ratio of 1.17 to 1. Then if the coal cost $1 delivered, its cost burnt under boilers is $1.15 and gasified $1.45. The fuel cost is proportional; therefore it is $1.15 × 1.17 = $1.34 for the steam turbine and $1.45 for the gas engine. That is, the heat units used by the gas engine are less, but the money cost of fuel is more.

This is all based on full load conditions; and while the cost for both goes up very rapidly for lighter loads, owing to the flatter heat consumption curve of the turbine and its small relative size owing to its much greater overload capacity, its heat consumption rises much more slowly, and as to the use factor in public service work is about 30 to 40 per cent it will be perfectly obvious that the advantage of the turbine over the gas engine will be much greater in the average than it is at maximum load, even in the heat unit basis. Of course, as the cost of coal rises the case becomes more favorable for the gas engine at full load, but it is very doubtful if under any ordinary commercial conditions its practical economy in the average is much higher than that of the turbine.

When we come to the iron industry we come to a different condition, very much more favorable to the gas engine. This is that the fuel to be used is already gasified by the blast furnace, this gas being in fact almost an ideal fuel for gas engines, and they are therefore entirely freed from any change or loss of heat for gasification, except that the sensible heat of the gas, 6 to 8 per cent in good practice, must be sacrificed to fit the gas for gas engine use.

The steam plant on the other hand is under the necessity of burning this gas under boilers with the same losses as occur in coal firing, except that the labor cost is very small. In the past the economy of furnace boilers has been extremely poor. I have tested boilers where it was down to 30 per cent and 50 per cent was about average practice until quite recently; but just at the present time this subject is receiving great attention and boilers are being operated at an efficiency of 75 to 80 per cent in regular work. In this case the full-load fuel consumptions are propoptional to $\frac{77}{1.77} = 0.66$ and 1.00 — 0.07 = 0.93, or 1 to 1.41, with the further advantage that the gas engine is enabled to dispense with one whole operation and its attendant bother—the gasification of the coal. Moreover, the gas engine has in this service a further great advantage. The use factor is about 60 per cent for electric service in the steel industry, while for blowing engines it is nearly 80 per cent.

Why, then, are these engines not in universal use in such plants? Here we come to the real milk in the cocoanut. We have hitherto said nothing of comparative labor costs and of capital charges. In regard to the former the gas engine has had a bad name. The stresses which it undergoes are tremendous and breakdowns in the past were frequent and serious, while the uncertainty of the engine going at all was a decided factor in its early days. But if you consider the

* From an address on "Modern Power Plants in the Iron Industry," delivered before the Engineering Association of the State College of Pennsylvania. Republished from *The Iron Age*.

prayerful uncertainty with which a man started out on an automobile trip ten or twelve years ago, not knowing when or how he would return, and consider our present entire disregard of this as an important factor, you will admit that many of the defects of that type of motor have been removed and that its reliability now fairly challenges that of the steam engine—a condition which is rapidly becoming, if it has not already become, true of the larger types which we are considering. Nevertheless, the number of parts and variety of their movements is vastly greater in this engine than in the turbine, and the cost of supervision and operation is correspondingly greater. But leaving this question for a few minutes let us turn to that of capital charges.

These are made up of straight interest and an additional percentage on the investment which is set aside and saved at compound interest, so that at the end of the reasonable life of the plant we may have a sum in the bank equal to the original investment, with which we can either pay off the investor or buy a new plant. Any operation which figures its costs on any other basis will probably go broke, and certainly ought to. Five per cent at compound interest will equal the principal in about 14 years, which is about all the life we have a right to expect from a power plant. If it is not worn out in that time, it has most likely been designed off the map; that is, later improvements will have made it commercially undesirable to operate any longer, even though it be not nearly worn out.

This 5 per cent added to 7 per cent of the interest rate which must be figured on industrial plants, gives us 12 per cent capital charges over and above all operating costs of every kind. This is a minimum figure for plants of this kind. Make no mistake. These are not bookkeeping figures, and the shores of commercial history are covered with the wrecks of plants which failed to provide for these charges. No sensible business man will put money into a property which cannot figure on this basis and still show a profit.

We see, then, that the annual cost of power is made up of fuel, labor and one eighth of the cost of the plant. Let me illustrate this: I know of a plant where a furnace is blown with two gas blowing engines which cost $107,000 apiece, and which with foundation, house, crane and gas cleaning apparatus and connections erected complete, did not cost less than $275,000. They develop together about 2,500 horse-power, or a cost of $110 per horse-power installed. Coal of 14,000 British thermal units in this region costs about $1 at the plant. Steam engines of the best type, with their boilers and all accessories complete could have been installed for $55 per horse-power. These engines would have required certainly not to exceed 18,000 British thermal units per horse-power hour, delivered to the boiler, while the gas engines may get along on 12,000. Counting 8,780 hours per year, the loss per year is 6,000 × 8,780 = 52,680,000 British thermal units. That is a tremendous amount of British thermal units, isn't it? But how much money is it? One ton of coal cost fired, say, $1.15 and contains 2,240 × 14,000 = 31,360,000 British thermal units. In other words it would require 1⅔ tons of coal per horse-power year to make up the steam plant's deficiencies, or say $2 worth.

The difference in fixed charges, on the other hand, are 12 per cent of (110 — 55) = $6.60, or a net loss of $4.60 per horse-power year by the use of the gas engine with 100 per cent use factor. On the other hand, gas blowing engines are now being built which can be installed for $75 per horse-power, and if these were used in a region where coal cost $2.50 per ton, the cost of make-up coal would be $4.20, and the fixed charges in increased investment would be 12 (75 — 55) = $2.40, or a difference of $1.80 in favor of the gas engine under these conditions. This is 9 per cent on the additional capital required for the gas engine and might be considered a paying, though by no means a startling investment. For, owing to the uncertainties of industrial earnings, investors are not commonly interested in them unless they can see a manufacturing profit of about 15 per cent, and it is obvious that any additional expenditure required should show this amount or over, to be justified. In this case the amount is 7 per cent interest and 9 per cent net saving, or 16 per cent in all. It is right in this range of conditions that it begins to be good business to install gas blowing engines, though some authorities would insist that at least 2 to 3 per cent larger capital charges should be assessed against the gas engine on account of its high rate of physical depreciation.

Turning now to the generation of electric power, we find the conditions different again, because we have in the steam side the turbine with the direct rotary movement and its great capacity, while on the other we have the relatively slow speed of the gas engine and the consequent high cost of its generator with probably greater friction and less efficiency than when connected to a blower.

For these conditions we may take costs of $70 and $50, respectively, per kilowatt installed, and heat consumption per horse-power of 12,500 ÷ 90 = 13,300 British thermal units per horse-power for the gas engine, and

$$\frac{12{,}500 \times 0.90}{77} = 15{,}600$$

per horse-power for the turbine, or 17,700 and 21,750 per kilowatt horse-power, respectively. The use factor is much lower in electric service than it is in blowing engine service. If we take 60 per cent we shall be liberal. This means that on account of peak loads, for which it is necessary to provide, the plant in the course of a year will only put out 60 per cent of its maximum rated power. This factor varies very much in different works, but is higher in all of them than in public service plants. The heat consumptions are about what may be expected under such conditions of loading, and are not altered by this condition, and neither are the costs, but the relations of these two are profoundly altered. The excess thermal units per kilowatt year at full rated capacity for the turbine above those for the gas engine are 8,780 × (21,750 — 17,300) = 39,071,000; and the coal to supply this at 31,000,000 British thermal units per ton is 1.26 tons at $2.50 per ton. This is worth $3.15, but the use factor is only 60 per cent, so only 60 per cent as much coal is required for make-up, and the value drops to $1.90, while the fixed charges are 12 × (70 — 50) = $2.40. In other words, in such a case the saving in coal would not pay all the capital charges on the increased investment, which therefore would be a bad one. Moreover, while the cost of labor and supervision for gas blowers may be no greater than that for steam engines and boilers together, undoubtedly their cost for gas-driven generators is greater than it is for steam turbines and boilers, and this increased cost would further throw the scale against the gas engine. But as the cost of coal rises conditions are reached under which the gas engine pays, while as its first cost falls the fixed charges fall also and tend to make its employment sound from the business point of view.

You will see now, I think, why John Doe in Tyrone, where coal is cheap, may be a fool to do what has paid Richard Roe well in Boston, where coal is dear, and the engine that is the most economical of coal may be far the most wasteful of dollars. A recognition of this must be at the basis of all sound engineering and the fact that it is not always realized by engineers has done more to deprive them of the standing in the business which they should have than any other one thing.

Salt and Its Relation to Nutrition*

COMMON salt is a commodity, the annual production of which is known to exceed 12,000,000 tons. Of this huge total a large share is used as a preservative or otherwise employed in industry, yet an immense quantity is deliberately added to the diet of mankind. It is said that an individual consumption of 20 grammes a day is not unusual. This average, sustained for a year, would amount to about 17 pounds. The ration appears surprisingly large when we observe that it may be as much as one quarter of the total weight of protein taken and equal to one twelfth of the combined starch and sugar which constitute our main dependence for running the human engine.

It is agreed by all writers on the subject of nutrition that only a small part of this salt consumption is necessary. The rest is dictated by appetite; it is due to the common liking for the salty flavor. Individuals are found who do not care for this and who are said to eat no salt. This means that they use none voluntarily at table and perhaps direct that none shall be used in the kitchen. Yet they continue to receive a small salt ration because some is present in most foods and there is reason to believe that this minimal supply cannot be dispensed with. Sodium chloride is the chief salt in the blood and in the other fluids of the body. It is accordingly plain that growth cannot be continued unless this compound is furnished along with the other necessary nutrients.

When full stature is reached the need for salt is doubtless diminished. It might cease entirely if it were possible to avoid all loss of salt in the excretions. This possibility is nearly but not quite realized. When a man fasts for several days the escape of sodium chloride from his system sinks to a low level but remains appreciable. It may be in the vicinity of 0.6 gramme in the 24 hours. In complete starvation this gradual loss is probably not out of proportion to the general reduction of weight. Hence it does not lead to an actual lowering of the percentage of salt in the body. A diet sufficient in all other respects, but lacking salt, might bring to pass such a lowering.

One interesting result of using a salt-free diet has been observed in the failure of the glands of the stomach to produce hydrochloric acid. This valuable aid to digestion and antagonist of putrefaction must be evolved from the chlorides of the blood. Apparently it is not secreted when the concentration of these substances in the blood is at all below the normal and this in spite of the fact that the chlorine ions of the gastric juice can probably be recovered quite successfully. The suggestion has been made that restriction of salt should be beneficial in cases where gastric acidity is excessive.

Bunge, an Austrian physiologist, has collected a great volume of data concerning the habits of different races as to the use of salt. It is evident that some people set a high value upon it while others do not care for it at all. Where it is prized it has often figured in maxims and metaphors. "To earn one's salt" is a familiar phrase which gains point from the common origin of the words "salt" and "salary." Bunge learned that a certain East Indian tribe used as the most solemn oath in their court procedure the formula, "May I never taste salt again if I speak not the truth."

A little investigation shows that the desire to add salt to the food is experienced most by those who are vegetarians or nearly so. Men who are strictly carnivorous abhor salt. Thus it was found by the agents of the Russian government that the natives of Kamchatka could not be prevailed upon to salt the fish which formed their entire diet. The supply of fish was uncertain and that which was saved to eat in the long intervals between catches decomposed in shallow pits. Still it was preferred to salt fish. We notice the same detestation of salt among carnivorous animals.

The Arctic explorer Stefansson has recently reported a striking instance of the objection to salt which accompanies the use of a flesh diet. The Eskimo, whom he knows so well, have little vegetable food. When he settled among them he was embarrassed by their demands upon his hospitality. Policy dictated that he offer them food on all occasions but there was every prospect that his stores would be rapidly depleted. The situation was relieved by a simple device. It was only necessary to salt the food moderately—merely to his own liking—to deter his visitors from making inroads upon it. The requirements of courtesy were satisfied and the provisions were conserved.

When a sample of food is burned as completely as possible the mineral constituents remain as ash. Chemical analysis of this ash leads to very different findings in the case of different foods. Several acids and bases will always be found. We will consider only the occurrence of sodium and potassium. The ratio between the quantities of these two bases is widely varied, though in the great majority of instances potassium is the more abundant. In animal foods the disparity is not marked but in most vegetable substances it is striking. For example, the proportion of potassium to sodium in meat (veal) is 4 to 1, while in potato it is more than 30 to 1.

Can we recognize a causal connection between the excess of potassium in a vegetable diet and the craving for sodium chloride which is attendant on the use of such a diet? Bunge maintains that we can. His explanation has been criticised in detail but is probably valid in its main thesis. The absorption into the blood of a quantity of salts, unlike those normally present there, imposes upon the kidneys the duty of restoring standard conditions. If the chief demand is for the removal of potassium compounds the task will soon be accomplished. But this will not be done without a considerable loss of sodium chloride. It would be remarkable, indeed, if the kidney cells could select all the foreign ions and not occasionally let slip some of the much more numerous native ones.

Bunge was able to demonstrate, upon himself, the fact that an excessive intake of potassium salts does lead to a loss of sodium chloride. He swallowed as much potassium phosphate and citrate as he could tolerate and subsequently excreted all the potassium—equivalent to 18 grammes K_2O—but simultaneously eliminated 6 grammes of sodium chloride. Such a draft upon the tissues could not be continued indefinitely unless salt were supplied in corresponding amount. Bunge's personal experiment was not an unreasonable one, for it is calculated that when potatoes form the bulk of a man's ration twice as much potassium may be ingested as in this trial.

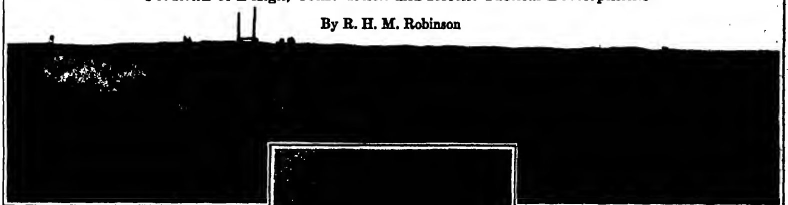
There is, therefore, no doubt that salt is a necessary addition to diets in which the ratio of potassium to sodium is unusually high. The instinctive craving for it is a marvelous instance of the almost infallible correctness of such impulses. Bunge has recorded the use by an African tribe of the ash of a certain tree as a seasoning for their food. Most kinds of wood reduced to ashes would yield a mixture over rich in potassium which would be a most undesirable adjunct to other articles of vegetable origin. But the tree in favor with these people was the rare exception; its ash contained a most unusual proportion of sodium compounds. It is rather painful to fancy the tedious succession of experiments by which the ancestors of this tribe eliminated various kinds of wood, and pleasant to imagine the satisfaction realized when the fortunate choice was finally made.

*By Percy G. Stiles in *Science Conspectus*.

The Submarine in Naval Warfare—I*

Problems of Design, Construction and Recent Tactical Developments

By R. H. M. Robinson



Driving into a choppy sea.

The United States submarine "G-2" running full speed at the surface.

When I accepted the Institute's invitation to address you, war had not been declared, but since its declaration the history of the submarine in warfare has been in the making, and so much has happened and was likely to happen, bearing on my subject, that I postponed preparing any paper until the last minute, and so, I fear, should apologize for it.

As an actual designer and builder of submarines I am fairly new at the game, though I have to draw on the accumulated experience and advice of my colleague, Mr. Simon Lake, one of the pioneers in the practical submarine field.

Most of my early experience in the field of design and construction was with surface warships, with which I may claim reasonable familiarity, having, during an eight years' tour of duty as assistant to the chief constructor of the navy, supervised the design of every dreadnought now in commission in our service and half of those now building, together with numerous other surface craft of all types.

It is, therefore, on my knowledge of the vulnerability of the dreadnought type to submarine attack as much as on my knowledge of submarines that I must base my right to talk to you.

In the beginning permit me to say that I am not one of those who believe the submarine a cure for all naval ills, or that it will supplant surface warships.

I am, however, and have always been, a strong advocate of the submarine as one of the most powerful naval weapons of defence, and as possessing offensive qualities which, in the fulness of time and with the development of engineering science, cannot be minimized.

The wording of my subject might imply that I expected to pose as a prophet, but I should prefer, if I may, to show you certain facts and in most instances to allow you to make your own prophecy.

Admiral Sir Percy Scott, of the Royal Navy, in his now famous letter to the *London Times* of June 5th, last year, took the strongest possible stand for the submarines and, incidentally, against the battleships, concluding his letter with the statement: "In my opinion, as the motor vehicle has driven the horse from the road, so has the submarine driven the battleship from the sea."

Coming as it did from one who had contributed so much to the development of the battleship offensive power, this letter made an enormous impression, though I cannot but believe that Admiral Scott stated the case somewhat more strongly than was justified or than he himself really believed.

What may very well be the case is that the effect of the submarine will be to reduce the rapid growth in size and expense of the dreadnought type, now reaching to almost unbearable amounts.

The menace of the submarine arises, first from her invisibility, and, second, from the fact of the difficulty of providing against the damage which will result from a blow from the weapon she carries.

Sir John Biles, LL.D., in a recent paper before the British Institute of Naval Architects, says:

"There can be only two forms of defence: first, the destruction of the submarine by other vessels, submarines or others; second, the protection of the bottom of the surface ships from the effect of under-water attack. The first, the destruction of the submarine, is obviously not the work of a battleship or large cruiser, but must be left to some vessel of the same order of size as the submarine. This destruction must be sought on the surface when the submarine is not submerged, for it seems improbable that a submarine will be able to chase another effectively under the water. In any case, the submarine will be dangerous to the large surface ships until it is destroyed, and, as the means of destruction are not yet certainly at hand, the question of effectively protecting the battleship against under-water attack seems to be deserving of consideration, unless some one is ready with a real reply to the submarine."

A great deal of attention has been given by naval architects to providing, in the dreadnoughts, protection against the automobile torpedo, with astonishingly small success up to the present time.

I personally struggled with this question for a good many years, and I believe, without conceit, that the United States has to-day as good a solution as has yet been obtained, but even that is by no means perfect.

For a ship at anchor a reasonable protection against the possibility of damage from the automobile torpedo may be obtained by the use of torpedo nets, although the development of the net cutter, attached to the torpedo's nose, has made even this uncertain. It is almost impossible to use a torpedo net on a ship under way. In the first place, it enormously decreases the speed and handiness and enormously increases the fuel consumption of the vessel wearing the net, and, in the second place, the mere fact that the vessel is under way causes the bottom of the net to rise to the surface and thereby largely does away with the advantage of the net.

This being the case, the only remaining possibility is to include within the structure of the vessel itself provision against damage by attack from a torpedo. Unfortunately, it is much easier to increase the power of the torpedo than it is to increase the defensive protection built into the hull of the dreadnought, with the result that, if any given class of surface ship has protection against the then existing torpedo, it is fairly easy to vitiate the value of this protection by increasing the power of the torpedo.

Briefly, the provisions which may be embodied in the design of a ship against the damage of the torpedo comprise under-water armor, additional compartmenting, and compressed-air installation for localizing the inflow of water. The under-water armor, on the face of it, looks like a good solution of the problem, but, as a matter of fact, it is of very little use to put under-water armor on the external hull of the ship. A torpedo explosion has a crushing effect, which results in tearing the riveted joints. The rivets seem to be attacked in detail, and an increase in the amount of metal applied externally does not do away with the necessity for riveted joints, and, if under-water armor were put on the ship in the same manner as the above-water armor, there would be no connection at the joints, since the armor above water is simply plastered up against a backing plate.

Careful and minute compartmenting, of course, covers a large number of possibilities, but provides only against the damage done by the torpedo in localizing the effect of the damage.

The compressed-air installation is a means of preventing water entering the body of the ship in too large volumes as the result of any damage done by a torpedo. It has to be specially applied, utilizing what is called the "backing up" method, using pressure in the adjacent compartments of varying degrees so as not to damage the ship's structure by the air-pressure.

The best solution of the problem is a combination of the three methods referred to above:

Proper compartmenting—and by this I mean something different from the time-honored system in use in the older days—under-water armor not located on the external hull of the ship and so designed as to give a maximum strength to the structure of the ship, and a graduated compressed-air installation for checking the water after it gets into certain compartments which cannot be prevented.

There are several essential features in designing a surface ship and in providing these anti-torpedo protective features which must be looked out for. The principal among these is the effect on the longitudinal or transverse trim of the vessel, from water getting into one or more compartments. The question of longitudinal trim is ordinarily not as important as transverse, and provision may be made, and has been made, for balancing transverse trim or list by admitting a similar amount of water on the opposite side to that damaged. This course results in a greater sinkage and consequent reduction in speed and safety of the vessel, but, when a balancing system is properly arranged in combination with the defensive means mentioned above, it should probably result in the ultimate salvage of the ship, although her value as a fighting unit after the damage from the torpedo would probably be little or nothing for the time being.

The British cruisers "Aboukir," "Cressy," and "Hogue," which were sunk by the German submarine "U-9," were, of course, not ships of the most modern type. They, however, represent a very excellent type of ship of some 15 years ago, and the fact that each of them sank as the result of a blow from a single torpedo indicates plainly enough the fact that a ship of very little age soon becomes practically out of it when subject to the danger of submarine attack.

The more recent sinking of the dreadnought "Audacious" brings this thought more forcefully to our minds.

The submarine, as you know, is not at all a new idea; in fact, some very excellent conceptions of submarines are quite old. Any one desiring to investigate this fact has but to read the interesting and complete work on "Submarine Navigation," by Allen W. Burgoyne, who rehearses the various types of submarines projected or

* *Journal of the Franklin Institute.*

Successful submarine attack at close range.

undertaken by all manner of people since before the beginning of the Christian era.

The list of inventors includes men of all nationalities and from all walks of life: doctors, clergymen, lawyers, military men, and mechanics.

Some of the projects were absurd, many were never undertaken, but others had excellent ideas, and were perfectly practicable, except in one essential particular: a proper prime mover for propelling and auxiliary power.

The early boats were, of course, propelled by hand, no other power being then known, and it takes little imagination to understand how laborious this was and how little speed or control could be expected from a craft so propelled.

It was not until steam had been used as a motive power in surface ships for many years that a really operable submarine was produced, and not until the development of the internal-combustion engine and the storage battery that the submarine became the well-developed instrument that we know to-day.

Strangely enough, there has been of late a return from the internal-combustion engine to steam in certain instances for surface propulsion, but so far the storage battery holds undisputed sway as a source of power for under-water work.

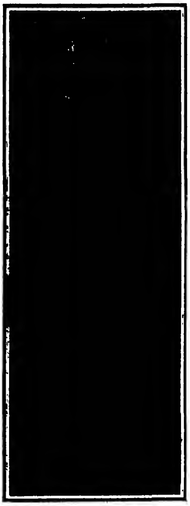
The submarine at present must carry two entirely distinct and separate sources of power, one for surface work and one for submerged work, and the storage battery per unit of power is very heavy.

I have kept before me for years a sign that reads: "The man who says a thing is impossible is apt to be interrupted by somebody doing it." So I shall not say that any means of under-water propulsion other than storage batteries is impracticable, but at the present time no other practicable means is apparent, and it is this very fact that is the greatest restriction confronting the submarine designers and builders.

The essential features of any submarine from a military point of view are surface speed, surface radius, submerged speed, submerged radius, and armament.

SURFACE PROPULSION.

The early successful submarines had gasoline engines. These were later superseded by heavy oil engines of the Diesel cycle—first, four-cycle engines, and, more recently, two-cycle engines, of which several types have been used. None of these can be said to be perfect yet, but great improvements have been made and are still making.



Observing by means of the periscope.

The high pressures and temperatures that occur in the Diesel engine result in stresses that are serious, and the high speed and comparatively light construction that must be obtained in submarine engines give a chance for trouble that might not exist in a slow-going installation.

STORAGE BATTERY PLANT.

The safety and success of the attack of a submarine depend to a great extent on her ability to approach the enemy while submerged and to remain submerged for a long while. In a high-sea engagement the enemy's fleet may naturally be assumed to be under way at some speed, so that the development of the sea-going type, to which some reference will be made later, will logically include some increased submerged speed and considerable increased submerged radius for manouvering in the vicinity of the enemy for a long period.

Increased submerged speed and increased radius of action submerged will make the batteries proportionately larger than are at present used.

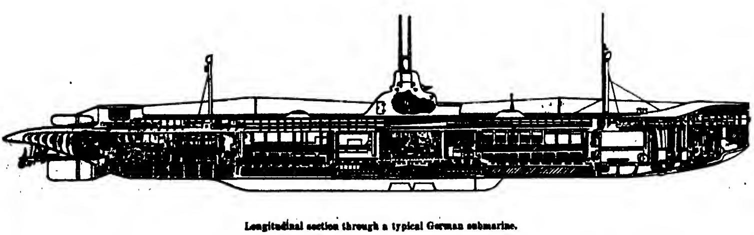
In the case of the sea-going type of submarine the design of the storage battery requires study in order to get the battery best adapted to obtain the maximum speed submerged and the greatest radius of action along with a reasonable length of life.

ELECTRIC PROPULSION ON THE SURFACE.

Owing to the mechanical difficulties involved in large reversible Diesel engine plants, it may be found advisable to design for a purely electrical propulsion—surface as well as submerged—using Diesel-driven generating sets, or turbine-driven generating sets driving motors on the surface. The present difficulty in the way of such installation is the size of direct-current motors required for constant duty on the surface.

To save space and weight, voltage up to 500 volts would suggest itself as feasible, or, as a compromise, to use 500 volts for surface running and 250 volts when running submerged, which would involve practically the same voltage as at present used on submarines.

The electric propulsion would involve one or more direct-current generating plants, and the propeller shafts



Longitudinal section through a typical German submarine.

would be supplied direct from the generators for surface running and from the storage battery for submerged running. The speed control obtainable from such an equipment is ideal.

Some propositions have been advanced for obviating the necessity of a duplicate propelling plant, utilizing the surface cruising engines also for submerged work. One of the most prominent of these, up to date, is the Del Proposto system, proposed by a Belgian engineer of that name.

To quote in part from a paper read by Mr. Del Proposto, the system is based on the following principles:

"The compressed air can first be regarded as a fluid with a potential power due to its pressure, and then as a chemical composition. Thus it can serve twice for producing energy: first, in a compressed-air motor, and then as feed for an internal-combustion motor. This twofold use of the same air for producing energy leads, evidently, to a reduction in air consumption per horse-power and a given lesser quantity of air to be stored on board for developing a given quantity of energy, and therewith also a reduction in the required weight of air tanks. Thus we come logically to the following conception of the boat, viz.:

"A boat or submarine diver of which the propulsion on the surface is ensured by an internal-combustion motor, which, during such run, can also actuate a compressor which stores air at high pressure in the tanks. During under-water runs the compressed air, reduced to a suitable compression by means of a reducer, passes first through a compressed-air motor, which need be no other than the compressor before mentioned, if its construction allows it, or one or two cylinders of the internal-combustion motor. Then the air is drawn up by the internal-combustion motor, which under water continues working exactly as on the surface. The air which has escaped from the compressed-air receptacle and drawn up by the internal-combustion motor remains in a closed vessel, but if we take note that this air has not lost its chemical qualities nor its composition, and, therefore, can well serve for the breathing of the crew, it is suitable to let it first escape inside the boat, whence it is drawn by the internal-combustion motor.

"In arranging the escape openings of the compressed-air motor on one of the ship's ends at the side where the crew usually is, and the suction of this motor at the opposite end, we establish inside the boat an artificial air current, continuously ensuring strong ventilation.

"It may be noted that, the escape passage of the compressed-air motor and the suction of the internal-combustion motor taking place in the same connecting tubes, it would be necessary to establish there a receptacle of great capacity, which would serve as regulator, intended to avoid the pressure variations at the entry of the internal-combustion motor. In the above indicated arrangement the whole inside of the boat acts as intermediary tank, and, consequently, the unchangeability of the pressure could be easily maintained. Seeing that the air which serves for the production of energy is used for ventilation of the boat, we have thus an automatic renewal of air without recourse to special apparatus."

I believe the construction of a boat embodying these principles was undertaken, but I am of the impression that its advantages were not all that had been expected. It serves, however, to indicate a possible line of solution, and one which would be desirable if it could be attained.

There have recently come forward several propositions of a somewhat different character, but a proven installation has not yet been produced.

PROPELLERS.

One of the most difficult problems to solve in connection with the design of a power plant for submarines—in fact, a problem without exact solution—is the design of a propeller suitable both for surface and for submerged navigation. There are two conditions to meet, which call for two distinct propellers. Broadly speaking, the first condition is to obtain a certain speed with a certain resistance to propulsion on the surface; submerged, the speed may be the same, but the resistance has increased, because the body to be pushed through the water has increase in volume and has changed shape. It is impossible to have two distinct propellers, and a propeller capable of having its pitch mechanically changed to suit conditions for the sizes now used in submarines has proved difficult to obtain in practice and of less efficiency than a compromise propeller to meet both conditions.

We are therefore driven to the design of a propeller to meet both conditions as near as possible. To do this we must decide which one is to be favored. Either the surface high or cruising speed or the submerged high or cruising speed can be favored, according to whether we are limited in obtaining power units large enough or in carrying fuel or storage battery capacity.

A safeguard is to design the propeller with an excess of area to make up for errors due to the non-fulfilment of the true pitch in both conditions and to the increase in slip due to the propeller turning faster to meet the increased resistance submerged, owing to the pitch of the compromise propeller being smaller than the pitch required for surface work. Hence the speed load curve of the electric motor should be higher in point of revolutions per minute than that of the internal-combustion engines. But this is not always possible, owing to the characteristic curve of electric horse-power required at different speeds, which is low in point of power at low speeds, compared with the engine load speed curve, which is nearly a straight line, and one has to keep the speed of the motor lower than the speed at corresponding power of the engine in the range of low speeds in order to meet the ship's electric horse-power curve.

Thus, given the engine's speed load curve, the safest course seems to be to design the motor so as to be correspondingly lower in speed for equal power in the range below half load, and higher in speed than the engine at corresponding powers in the range above half load. Then design the propeller with pitch between the pitches required for two propellers designed for each condition separately, with an excess of area and favoring the condition where there are deficiencies, and, finally, making the propellers with adjustable blades so as to be able to modify the pitch during the trial trip.

This is my idea of meeting conditions, subject to further observations during trials to come in order to discover points open to correction. Past performances only, compared with future results, can point out the most effective way for meeting and overcoming the difficulties in this line.

SAFETY V. EFFICIENCY.

The tendency of the United States Navy Department's requirements is in the direction of multiplicity of safety devices and escape hatches, greater watertight subdivisions, etc. While this may increase efficiency by giving the crew greater confidence, additional hatches are really a source of danger, and close subdivision interferes with economical arrangement of the interior.

I believe the dare-devil type of man who would naturally choose submarine service would rather have more effective means for dealing with the enemy and take any reasonable chance on his own safety.

Of course, the Navy Department, under a Government such as ours, has to keep the political and public-opinion sides of the question in mind.

DEPTH OF SUBMERGENCE.

Heretofore all United States submarines had to be subjected to a test depth of 200 feet from the axis, while all foreign submarines have been contented with 40 meters. This, in itself, is a penalty on the design of United States submarines, adding, as it does, to the weight of the hull and so increasing the size and cost of a given type of boat.

At the present time the opinion seems to be growing in the United States service that a test submergence depth of 150 feet is sufficient. This means probably that, with improvements in design and growing familiarity with the handling of the vessel, the submarine operators are becoming satisfied that they will be able to avoid accidental submergence beyond this depth if they can check the sudden downward movements at all, and, if they cannot stop her before reaching 150 feet, the chances are they could not before reaching 200 feet, anyway, and therefore adopt 150 feet and save weight for other purposes.

As I understand it, the 200-foot test was originally based on consideration of the depth along the Atlantic coast, 10 or 15 miles from shore, on the theory that a vessel might go to the bottom and still be O. K. if she could stand 200 feet.

As in all other types of naval ships of war, the submarine has two general rôles, defensive and offensive.

Defensive operations include:

Harbor defence, which, at the beginning of submarine development, was regarded as a primary duty.

Coast defence, an amplification of harbor defence, rendered possible by increase of radius of action and habitability, in virtue of which the submarine may be used to prevent landing in force or other operations along the coast anywhere within limits, equal, roughly, to early half their radius of action.

Offensive operations include:

Destruction of vessels with which the enemy attempts to either hold or control the sea or to carry on military operations.

Attacking the enemy's ships and ports.

Operations in conjunction with the fleet on the seas.

On account of the extensive coast line of the United States, submarines in number seem essential for use in *defensive operations*.

On account of the geological location of the United States, the value of submarines for attacking enemies' ports is, for over-sea enemies, smaller than is the case with European powers. In their use for the destruction of vessels with which an enemy attempts to hold the sea or for use in conjunction with the fleet, a type of boat somewhat different than that required for the strictly defensive operations would necessarily result.

From the point of view of the United States, it would seem that the desideratum is an adequate number of submarines that will actually do what is required of them theoretically; i. e., some for defence near our home ports and bases, and some for operations with the fleet on broader defensive lines. To be able to obtain an adequate number it is essential that the necessary features be obtained with the least possible displacement and at the least possible cost.

For the protection of the harbors on the east and west coasts of the United States, it has been estimated by a naval authority that there should be a group of five coast defence submarines and one suitable tender stationed at each of the harbors and places which are considered worthy of protection for strateg'cal reasons.

It has been estimated that for the proper protection of the east and west coasts of the United States there should be a total of fifty-five coast defence submarines on the east coast and a total of forty-five coast defence submarines on the west coast.

No mention is made above of submarines for the defence of our over-sea possessions, such as the Panama Canal, Atlantic and Pacific ends, Guam, Hawaiian Islands, and the Philippines, but it is believed that at least one mobile tender in combination with a group of five coast defence submarines would be needed in each such locality, with probably several groups in the Philippines, to prevent effectually the operation of a hostile fleet in these waters.

One occasionally reads of submarines of destroyer speed, which to the layman appear entirely practicable and to the military man highly desirable, but to the submarine man it seems impossible, and certainly is to-day, meaning, as it does, about 30 knots on the surface.

The advent of the large sea-going type of submarine is a logical development in submarines, and there seems little doubt but that in the future two distinct types of submarines will be recognized to be needed, namely, a small type designed for harbor defence or coast defence, and a large type or sea-going submarine, capable of accompanying the fleet even to the waters of the enemy's country and supporting the battle fleet in a fleet action.

The essential features of the small type have already been worked out and are in successful operation and genera'ly known, so that new development of the equipment of these boats will naturally be slow, but the conditions that the sea-going type must meet give an opportunity for increased development, particularly in the propulsion plant, both for surface work and submerged operation.

The present type of submarine, of which our navy has a considerable number, have a surface speed of from 12 to 14 knots, with a radius of action at 9 or 10 knots of from 1,500 to 4,500 miles. Such boats range from 250 to 550 tons displacement submerged, and have fairly small reserve buoyancy.

For a purely defensive type of submarine the 4,500-mile radius is, in my opinion, entirely unnecessary, and requiring it results in a boat of considerably greater cost and size than is necessary to perform the work which it is intended to do and is capable of doing.

The sea-going fleet speed submarine, to be used in conjunction with the fleet, is quite another matter, and the provision of long radius of action is not only justifiable, but necessary.

Considerable prominence has been given recently to the giant submarine projected by our Navy Department. What is really aimed at is a sea-keeping submarine for service with the high-sea fleet.

Public policy prevents my entering into details of the vessel desired, but there is no impropriety in my discussing briefly the general principles of such a design.

Foreign powers, by which I mean England and France, have undertaken, but not yet completed, a submarine of some 18 to 20 knots surface speed and with submerged speeds of 13 or 14 knots.

Complete details of such vessels are not available, but they naturally lead to dimensions far in excess of those of submarines now in our service.

For submarines of the coast or harbor defence type it is usual to have a hull of circular cross-section, sometimes modified toward the extremities into an ellipse, with its major axis horizontal or vertical, as required by conditions.

After exhaustive investigation I am convinced that for vessels of moderate speed requirements this form is, all things considered, the best.

(*To be continued.*)

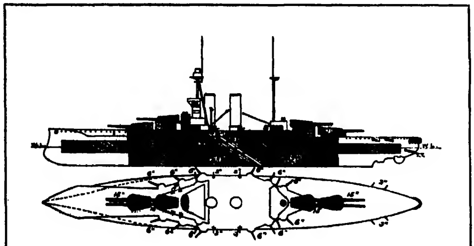
The U. S. Geological Survey has thus far surveyed topographically about 1,200,000 square miles, or nearly 40 per cent of the United States, as well as 170,000 square miles in Alaska. Nearly 2,300 quadrangles have been mapped on various scales, generally 1, 2, or 4 miles to the inch. These maps show minute details, even to individual houses existing at the time of the survey. The extent to which they are used is shown by the fact that more than 1,000 copies are sent out daily on an average.

The Super-Dreadnought

The influence of H. M. S. "Queen Elizabeth" on the progress of the Allies' attack on the Dardanelles forts has given the coup de grace to the advocates of smaller battleships. In the very early days of the war we stated that among the problems that had faced military and naval engineers during the many years that they were building material which was never tested in hostile operations, the greatest of all naval problems—the dreadnoughts versus White ships—would be settled. We must admit that at that time we expected the great test to be made in a general fleet action, and in the absence so far of that ultimate trial it is still open for the advocates of the smaller vessels with mixed armament to claim that the decision is not final. But they must be very determined opponents indeed who refuse to admit that the dreadnought battleships and cruisers have fully justified the advisers of the Admiralty in their decision to build them. The "Queen Elizabeth" has, however, given us all a surprise, not only by her sudden appearance in an unexpected quarter, but by the effect she has produced. In all discussions we have heard, and in most we have read, on the relative value of the big and the medium-sized battleship, the basis of comparison has always been two hostile vessels or fleets in action; attention has rarely, if ever, been directed to the attack on permanent land defences. It was either tacitly assumed that a fleet would always have to run the gauntlet of a general action before an attack on shore defences could be attempted, or Admiral Mahan's dictum, that a fort could always beat a ship of equal monetary value, had been carried further than the author intended. In the first alternative, competition with enemy ships was the criterion, and as the question of the attack on forts was dependent upon the power of a fleet to destroy its opponent on the high seas, it was neglected as of only secondary importance. The second alternative, that powerful forts could not be successfully attacked, has presented the revelation of the war, both on land and sea, and it is hardly surprising that it escaped attention. Until the Germans showed us what could be done against great fortresses it was the general belief—as much, no doubt, in Germany as in other countries—that such defences could hold out for long periods. Until the allied fleet, with enormous guns of long range aiming into the blue, under the direction of aeroplanes and watching ships, effected the destruction of the forts in the Dardanelles, no one had considered the possibilities of such things; the surprise the Germans gave us ashore, we have given them afloat, and forts as a means of defence, at least forts of the kind we now know, are discredited. Admiral Mahan's dictum must clearly be re-written or re-read. That great critic sympathized with Sir William White's views about the size and armament of battleships, but it is probable that, had he lived longer, and had witnessed the effect that the 15-inch gun has had at the Dardanelles and that the 13½-inch guns had in the North Sea action, he would have somewhat modified his views.

The "Queen Elizabeth" has opened new and astonishing possibilities which must be causing grave anxieties in Germany. She is but one of five sisters; one other, the "Warspite" (Devonport) may already be at sea, she was laid down about the same time, and was due for completion in October last. The "Valiant" (Clydebank) and the "Barham" (Fairfield) were due for completion last month, the "Malaya" (Elswick) should be drawing toward readiness for sea. Speaking of these vessels, when introducing the last navy estimates, Mr. Churchill dealt with the guns at some length. The passage is of more than ordinary interest at the present moment and we quote it in full: "One of the most important decisions that the Admiralty have had to take for many years was the advance from the 13.5-inch gun to the 15-inch gun. Two years ago we knew that other countries had already decided, and had actually begun, in some cases, to adopt a number of more powerful weapons than we possessed in the 13.5-inch gun. In the "Queen Elizabeth" type we wished also to have exceptional speed without any loss of gun power or protection or undue increase in displacement. We had thus to give up one of the five turrets to find room for the extra boiler power, and in order to maintain our gun power we had to increase the caliber of the guns. Thus we had eight 15-inch guns instead of ten 13.5-inch guns. There is no great difference in cost involved in this. But what is remarkable is that while other countries were debating and experimenting we acted. We ordered the whole of the 15-inch guns for the ships of the 1912-13 programme without ever making a trial gun. We trusted entirely to British naval science in marine artillery, and to the excellence of our gun-making system and to the quality of British workmanship. When the first of those 15-inch guns was tried a year ago it yielded ballistic results which vindicated, with what is to the lay mind marvellous exactitude, the minutest calculations of the designer. It is the best gun we ever had; it reproduces all the virtues of the 13.5-inch gun on a larger scale, and it is the most accurate gun at all ranges that we have ever had, and as it is never pressed to its full compass by explosive discharge it will be an exceptionally long-lived gun. Its power may be measured by the fact that whereas the 13.5-inch gun hurls a 1,400-pound projectile, a 15-inch gun discharges a projectile of nearly a ton in weight, and can hurl this immense mass of metal 10 or 12 miles. That is to say, there has been an increase of rather more than 30 per cent. I am purposely vague on this point in the weight of the projectile for an addition of 1½ inches to the caliber. This increase in the capacity of the shell produces results in far greater proportion in its explosive power, and the high explosive charge which the 15-inch gun can carry through and get inside the thickest armor afloat is very nearly half as large again as is the charge in the 13.5."

If one ship with these fine weapons could do what the "Queen Elizabeth" has done, what may not four more do? New vistas of the part of Great Britain in the war and the influence of sea power are offered. These considerations must have occurred to the Germans, and we may well believe that the thunder of the 15-inch guns in the Ægean Sea sounds all too close to their ears.—*The Engineer.*



Outboard profile and deck plan of super-dreadnought "Queen Elizabeth," showing guns and armor plate.

The Indicating and Recording of Time

The indication of time has long been one of the most important factors in the history of the world. Even the primitive peoples had some crude methods of telling time, usually by the sun, and one of the first implements used for the purpose was a vertical pole stuck in the ground to establish the noon mark. Representative types of early time-keeping apparatus and mechanisms from various countries are to be seen in the U. S. National Museum at Washington, D. C. This collection consists of permanent and portable sundials, hourglasses, time candles and lamps, a large series of watches and watch movements, and clocks, including a water clock of the seventeenth century.

Among the sundials, which are perhaps the best known of the early time indicators, is a model of one used by the Montagnais Indians of Canada, consisting of a pole set vertically, the shadow of which was marked in the snow by each hunting party to indicate the time of its arrival to the Indians who followed, thus making the passage of time calculable. Other interesting specimens are brass and ivory pocket sundials of the fifteenth and sixteenth centuries. There is also a ring dial which, when held vertically, permits the sun to shine through a small hole on one side of the rim and register the hour on a scale on the opposite side. Vertical and horizontal dials from many countries and latitudes, dating from the fifteenth to the twentieth centuries, are represented.

One of the most primitive time recording devices employed by the Chinese and Japanese, was a knotted wick about 2 feet in length, which smouldered without breaking into flame, and indicated the passage of an hour by the time consumed in burning between two knots. King Alfred is credited with having established a system whereby 12-inch wax candles were divided into equal distances; relatively a third of an hour being required to burn an inch. A candle of this type, but only 10 inches in length, is exhibited in the museum collection.

Philippe II. of Spain is supposed to have used an oil lamp for indicating time, the decrease in the amount of oil being shown by graduations on the glass reservoir. It was designed especially for night use; the graduations started at the top, with the mark IIII, passed downward to XII, and then from I to VIII, covering the period of winter darkness. A similar lamp is in the National Museum exhibit, classified as a pewter time-indicating lamp, marked for the hours nine to six, and was collected in 1900 in Nuremberg by Dr. Samuel P. Langley, late secretary of the Smithsonian Institution.

Sand glasses are represented by seven specimens of various types indicating 3 minutes, ¼ hour, ½ hour, and 1 hour, and one German set of four hour glasses probably of the fourteenth century. The hour glass is said to be the invention of Luitprand, a monk of Chartres, who, near the end of the eighth century, revived the art of glass blowing. These instruments are still popular with many clergymen, and it is understood that one is in daily use in the British House of Commons.

Clocks operated by water power date back as far as 300 B. C. in Egypt, and although their history is somewhat vague, it is believed that the earliest ones indicated "hours" of uneven length, while those evolved during the seventeenth century and later were simpler and showed even periods. Clocks of this description and of this period are known as Clepsydras; one with an alarm attachment was collected for the museum by Dr. Langley in Paris. It consists of a hollow drum, partly filled with water, suspended from an oblong frame by two cords, the lower ends of which are wrapped about the shaft of the drum. When the cord is wound about the shaft, the drum is at the top of the frame, and if released would descend rapidly, unwinding the cord as it goes, were its speed not regulated by the action of the water which flows slowly through a series of seven compartments within the drum, causing a drag or counterbalance to the action of gravity. The ends of the shaft act as indexes pointing to the hours marked on the frame.

The date of the introduction of clocks worked by weights is not definitely known, but it is supposed that they did not appear until the thirteenth or fourteenth century, and that John Megesten of Cologne invented the escapement. The museum displays a number of these clocks, including a ship's clock which rings "bells" in sea-going style.

Portable time pieces appeared shortly after 1500 as the invention of Peter Henlein of Nuremberg, who employed a long ribbon steel spring to drive the mechanism of his watches.

The museum collection of watches and movements numbers several hundred, and illustrates the development of the mechanical part of the watch, making it possible to compare the work of many early watchmakers of this and other countries.—*Bulletin of the Smithsonian Institution.*

Electro-Percussive Welding

An interesting variation in the many methods for the electric welding of metals, particularly where the two parts are different metals, was described last fall at the meeting of the Electro Chemical Society by C. E. Skinner and L. W. Chubb. In this system, which is called an electro-percussive method, a condenser discharge is passed between the ends of the parts at the moment when they are pressed together by mechanical force. An intense heat is generated so suddenly that it is entirely localized, and there is no time for the unequal conduction of heat through the bodies of metal, and the adjoining ends will be melted, whether the melting points be low or high. For this reason metals of different kinds can be welded together independent of their electrical resistance, melting point or heat conductance. For example, lead and iron can be thus welded, but such joints will not be permanent.

Recognizing Vocations from the Teeth

A Phase of Occupational Diseases That Has Received Little Attention

If we except phosphorus poisoning in the match industry, there is in the present day movement of caring for the workmen in the various trades one phase of the occupational diseases of which we hear comparatively little. This is the effect of different trades or occupations on the teeth and is ably discussed by Dr. M. Krause in a recent number of *Die Umschau*.

Not only do the teeth become decayed or otherwise diseased, or changed in shape, but they even are worn or dissolved away to such an extent that only stumps remain, and this due to a variety of causes, not only to lack of care.

A good example of the first-mentioned case is furnished by confectioners or candy makers whose front teeth particularly, are prone to decay followed by subsequent discoloration of the exposed dentine, due to the constant breathing in of sugar dust.

Fig. 1.—Confectioners' caries.

With workmen in chemical factories, where acids are manufactured or used in large amounts, "the process of destruction is not in any respect like the ordinary tooth decay but is a decomposition of the inorganic constituents and a devitalization of the organic constituents of the teeth."

In describing the effects of acids the author, who relies to a considerable extent on what is told to him, tells us that "the subjective sensation is alleged to be above all, a feeling of dullness in the affected teeth; these become so sensitive to change of temperature and to contact with sour, sweet and salty foods that every partaking of nourishment almost becomes a torture. This sensitiveness disappears when the process of destruction has assumed greater proportions." (Figs. 2 and 3).

Fig. 2.—Acid necrosis of the large incisors of the upper jaw of a chemical factory workman.

"The front teeth on account of their location and arrangement are the first to suffer since they are earliest exposed to the injurious influences."

It is observed that in metal workers, who are neglectful of the care of mouth and teeth, almost half of the exposed surfaces of the teeth, from the gums upward are covered with a dirty green coating. The workmen believe that they have "verdigris" on their teeth.

Dr. Krause was repeatedly able to convince himself that "as this coating may still be detected after a change of occupation of some duration, it may be designated and utilized as an important characteristic indication of occupation."

This deposit is caused by the "unavoidable metal dust which arises during the work and settles on the teeth during breathing, combining with the tartar coating of the neglected teeth."

The wearing away or roughening of the edges of the teeth is well illustrated by shoemakers who continuously use nails and brads of different sizes, which they usually

Fig. 3.—Acid necrosis of the lower middle incisor.

hold in the mouth and which thus serves as a handy container. "When a nail or wire brad is required the tongue pushes it between the biting surfaces of the incisor teeth. There it is held fast until required for use."

This results in the formation of coarsely jagged edges on the incisor teeth.

"Only when the nails are continually pushed between the middle incisor teeth will semicircular substance erosions sooner or later result, which are similarly found in upholsterers."

As to the effect of their trade on their teeth, we quote

Fig. 4.—Teeth of a glassblower, showing the rhombic opening formed by the revolving pipe.

the following in regard to glassblowers: "In order to form the glass mass into a desired shape, glassblowers make use of a long iron tube, sometimes provided with a brass mouthpiece. This is the so-called 'glassblower's pipe' which is held between the lips and teeth and is turned during blowing. From this worn concave surfaces result on the middle incisor teeth, which when closed, show a rhombic or diamond-like opening characteristic of glassblowers." (Figs. 4 and 5).

All those whose occupations compel them to use the sewing needle, that is, tailors, modistes, corset makers, etc., show "slit shaped grooves on the cutting edges of the incisors, and according as the possessor is right or left handed, running from right to left or *vice versa*, either slanting or in the center of the cutting edge in the direction of the cutting plane." (See Fig. 6).

The cause is that most workers in this trade, male and female, bite or tear off the thread with the incisor teeth before threading their needles.

"If they have the habit of firmly holding pencils between their teeth occupational indications are also evi-

Fig. 5.—Teeth of a glassblower. The middle incisor teeth show round worn off surfaces.

dent on the front teeth of teachers and draughtsmen, thus causing concave substance erosion."

"It has been proven that the habit of placing nails in the mouth and replacing those not used in a box in common use has been the cause of the transmission of syphilis. Also tuberculosis and other infectious diseases are certainly spread by such abuses."

Syphilitic infection has likewise been reported among glassblowers. For this reason shoemakers, upholsterers and glassblowers should be cautioned as to the danger of their manipulations, and the abolition of these abuses vigorously demanded. "By this means a great amount of misfortune will be prevented."

Fig. 6.—Teeth of a dressmaker. Note the grooves which have resulted from biting off the thread.

The article concludes with this excellent advice: "As experience in other occupations has shown that notices and posted regulations do *not* receive the deserved attention, we need not expect much result from this method in workshops. The lever for enlightenment and education should already be applied to the apprentices while at the trade schools. It is there that we should by means of words and pictures emphasize the great danger to life and health of such customary abuses."

Relics from the Second Grinnell Expedition

Through the recent death of Mr. Amos Bonsall, the last survivor of the second Grinnell expedition, which set out for the Arctic regions in May, 1853, in search of Sir John Franklin, there has come into the possession of the U. S. National Museum several relics and mementos of that notable undertaking, which have been donated to the museum by the daughter of the explorer. The collection includes gold and silver medals presented to Mr. Bonsall by the British government, and a daguerreotype made after his return from the expedition in 1855. A pair of polar-bear skin boots made by him an English rifle, an English knife, with a carved ivory handle of Eskimo manufacture, and a "sou'wester," originally from the Arctic expedition of Sir John Ross, all used by Mr. Bonsall during his explorations, and a pair of skin stockings and fur boots manufactured by the Eskimo are also on exhibition.

This exhibit is displayed in the north hall of the older National Museum building in connection with other Arctic relics. It recalls vividly the hardships suffered by the rescue party sent out in the brig "Advance," under the direction of Dr. E. K. Kane, U.S.N., which were so graphically reported by the commander upon his return.

Some of Mr. Bonsall's experiences were very thrilling; his report of a sledge journey made by six of the crew and himself to establish provision stations along the coast of Greenland is a remarkable story of adventure. It records a most perilous trip, over the ice and frozen land, in September and October, 1853, and when the temperature was far below zero. At the very outset, their sledges broke through the ice, precipitating several of them into the sea. Shortly afterward they came to an impassable opening in the ice extending for miles on either side of them, forcing them to await the rise of the tide to close it up. The author mentions one night's sleep on melting ice which soaked their buffalo robes, rendering the members of the party "extremely cold and uncomfortable"; incidentally their socks froze to the soles of their shoes. Sometimes the cold was so severe that they could not sleep, in spite of their exhausted condition after the forced march of the day. The fuel gave out, the only watch key was lost, preventing the recording of time; all the thermometers were broken, and nearly every member of the little band suffered from frozen feet, fingers, or faces.

Despite their misfortunes and sufferings, they established three *caches* of provisions, marking each with a cairn of rocks. Their progress was often very slow, some days only eight or ten miles were covered, owing to the rough ice, cracks and barriers encountered, but on others they managed to make as many as twenty-five. Often they had to ferry their sledge and themselves across stretches of open water on cakes of ice, a very dangerous undertaking.

On another trip in March, 1854, a rescue party, of which he was a member, suffered even more severely, and all of them were ill for some time after their return to the ship, from delirium, scurvy, frost bites, and other causes. Mr. Bonsall was the first to return with directions for the care and attention of the others, who, when they arrived, were covered with frost and ice, and so chilled and exhausted that they were unable to recognize their comrades on the "Advance." For sixty-six hours they had been constantly on the move, with very little to eat and even less to drink, during which time they had traveled between eighty and ninety miles, most of the way dragging a heavy sledge laden with four helpless men. As a result of this exposure, two of the men died, and several were forced to undergo amputations of frozen members, but the others recovered after a trying siege which turned the ship into a hospital of sick and insane men.

The tale of adventure connected with the few remaining relics of this heroic band, of which Mr. Bonsall was a member, makes an interesting page in the records of American Arctic explorations.

Italian Military Aeroplanes

Interesting Types of Craft for Air and Water

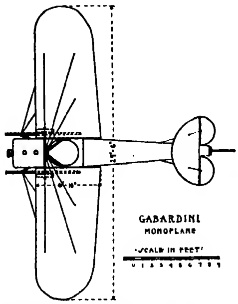
By John Jay Ide

MILITARY aviation in Italy dates back to the winter of 1908-9 when Wilbur Wright after his triumphs in France taught Lieut. Calderara to fly at an aerodrome near Rome. The government did little to encourage the industry and by the end of 1911 there were only 20 aeroplanes in use. There are now almost 200 machines of which 150 are of the latest models.

The machines of domestic design and construction are generally of the monoplane type inspired by Nieuport with sometimes a dash of Blériot or the defunct Hanriot. Only two makes of native biplanes are used: the Spa-Faccioli and one model of the Asteria. Both makes are comparatively slow; fast scouting biplanes have yet to make their appearance in Italy.

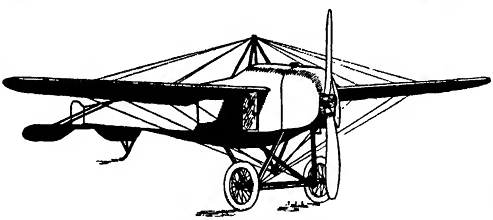
Until 1914 all the Farmans used by the Italian army were imported from France. Early last year, however, the Savoia Company which had acquired the manufacturing rights for Henry and Maurice Farman biplanes opened a huge factory at Milan covering 20,000 square yards where large contracts are being carried out for the government. Other foreign machines produced under license by Italian firms are the Blériot, Bristol, Deperdussin and Nieuport.

One of the most successful Italian monoplanes is the Gabardini produced at Camari, Novara. Although the machine is not dissimilar to the Nieuport in general outline there are several special features incorporated in the design. The fuselage, constructed of steel tubes reinforced with wood, has quite an original form. The forward part, from the nose with its 80 horse-power Gnôme to the rear of the cockpit, is rectangular in section. Behind the seats, however, the lower longerons meet and from this point to the stern the fuselage is of triangular section. The above arrangement while giving a good stream-line form allows ample room for the engine, fuel tanks and occupants. The triangular portion of the fuselage can be detached for purposes of housing and transport.



770 pounds; useful load, 770 pounds; speed, 40 to 85 miles per hour. A hydro-aeroplane model is also produced by the Gabardini firm. It differs from the land machine in dimensions and in the alighting gear, the latter of the two-float type.

Another prominent monoplane is designed by Sig. Caproni and constructed at Vizzola Ticino. Several models are made including single, two and three seaters, generally furnished with Gnôme but occasionally with Anzani motors. With an 80 horse-power Gnôme the two-seater is slightly faster than the Gabardini, due in part to the stream lining of the top and bottom of the



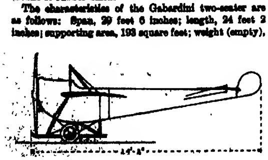
The Chiribiri monoplane.

The two spars of each wing are of tubular steel. On these the ribs are loosely mounted so that they possess a certain amount of flexibility when warping takes place. The ribs are of I-beam section with the webs drilled for lightness. The fixed tail plane and elevating flaps are copied from the Nieuport but they are placed well forward of the rudder giving the latter a wide range of movement. All the members of the empennage are constructed of steel tubing covered with fabric.

A lever mounted between the pilot's knees operates the elevators and wing warping. The rudder is controlled through pedals.

The chassis, on Hanriot lines, consists of two skids joined to the fuselage by three struts each. A tubular axle carrying a pair of wheels is slung from the skids by means of rubber bands.

The characteristics of the Gabardini two-seater are as follows: Span, 29 feet 6 inches; length, 24 feet 2 inches; supporting area, 193 square feet; weight (empty),



fuselage and the small head resistance of the chassis. Sections are cut out of the wings at their roots to improve observation. The Caproni works also build Bristol biplanes under license.

The Chiribiri Company of Turin build both single and two-seaters equipped with motors of their own make. Their 60 horse-power racer is credited with a speed of 103 miles per hour. The standard models are by no means rapid, doing only about 70 miles per hour with an 80 horse-power motor. The general design presents nothing unusual, the chief claim to distinction lying in the employment of a stationary motor. The Antoni monoplane is also of the conventional type, the Nieuport design being followed throughout, even to the chassis, consisting of two wheels and central skid.

The latest Macchi production is a Nieuport of the "parasol" type (having the plane over the pilot's head) with a Morane landing gear. The Friuli monoplane is a small Blériot type, single-seater, equipped with a 35 horse-power Anzani radial motor and a Hanriot landing carriage. Very few machines of this make are used in the army.

Biplanes and monoplanes are made by the Asteria Company located at Turin. Both types are driven by propellors instead of the more usual tractor screws. Gnôme motors are used on the monoplanes and Renaults on the biplanes. The only other Italian designed biplane is the SPA-Faccioli manufactured by the SPA automobile firm of Turin. It is a two-seater equipped with a 50 horse-power SPA motor and has a simple two-wheeled landing chassis.

An interesting seaplane is Lieut. Calderara's "hydrovol," a hydro-monoplane of over 60 feet span. The passengers are carried in a hull forming the center float of three, connected by a couple of spars. The axis of the propeller, driven by a 160 horse-power Gnôme is slightly below the huge wings which are mounted almost 8 feet above the floats and joined to them by vertical struts. From the outer struts spring the booms carrying the tail plane, elevators and rudders.

The outer floats, equipped with small water rudders at the stern, are divided into a number of watertight compartments with internal lattice frame. The hull is formed of three skins of wood with sailcloth between adjoining skins. If necessary the wings can be cut away and the central hull used as a boat.

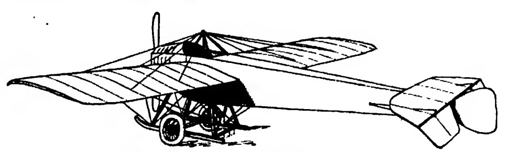
Flying boats—in this case biplanes—are also built by the Bossi Company. Many of these craft have been sold to foreign navies and they are likewise popular in the Italian navy.

Captain Guidoni supplies Farman biplanes and Nieuport monoplanes equipped with special floats of his own design. In each case there are two long floats, each fitted with parallel fins.

The Italian navy has acquired a large number of Curtiss flying boats, including a duplicate of the "America." The fleet of the 90 horse-power standard model is now being considerably augmented. In this connection a paragraph recently appeared in the daily press to the effect that Italy was about to place an order for 800 aeroplanes with American constructors. Our manufacturers in their present condition would take several years to fill such an order. The training of pilots and observers to man this multitude of machines would be incidentally a formidable task. From an authoritative source I have learned that an order would probably be forthcoming but would not amount to one tenth the above mentioned number. American firms, therefore, need not start work on additions to their plants just at present.

The Italian army machines are divided into squadrons of ten aeroplanes each. Seven machines in a squadron are always on active service while three are held in reserve. The Mirafiori aerodrome near Turin is the principal military flying ground. Acceptance tests for aeroplanes and motors, and examinations for pilot certificates are made here. The central school for brevets is at Aviano and three miles away at Pordenone is the training ground for those who desire to obtain superior brevets. There are several other aerodromes restricted to certain makes of machines. The central marine flying school is at Venice.

The most popular motor is, of course, the Gnôme made under license at Turin. The Anzani radial motor is used to some extent, as are stationary motors produced by FIAT and SPA. These last, however, are generally restricted to airship work.



The Chiribiri from the rear.

Copper Cyanide Plating Solutions*

Valuable Facts Relating to Their Composition, Action and Results

By Dr. Max C. Weber

I HAVE chosen as a subject the working of a copper bath, as this is by far the most extensively used and also the most instructive solution.

There are three things which are necessary for the deposition of metal—current, electrode, and electrolyte. As the electrolyte or plating solution is the most important, I will confine myself to this item.

The object of employing cyanide solutions for the deposition of copper is to be sought in the fact that in such solutions iron does not replace copper, notwithstanding their places in the electrolytic series, a phenomenon which is due to the complexity of the salt in which the copper is present. The complex salt, which makes this feasible, is the double cyanide or sodium copper cyanide, the anion of which is Na, the cation $CuCy_2$; that is, by the action of the electric current, Na travels toward the cathode, $CuCy_2$ toward the anode. In other words, copper is not present in an ionized stage. Under proper current conditions, i. e., not too high current density and a suitable concentration of the solution, Na is not discharged at the cathode, but reacts with an undissociated part of $NaCuCy_2$, as per the following equation:

$$Na + NaCuCy_2 = Cu + 2\ NaCy.$$

thus showing that the deposition of copper is a secondary reaction, and that free cyanide is formed. On the anode, the anion $CuCy_2$ combines with the copper of the electrode, forming cuprous cyanide $CuCy_2 + Cu = 2\ CuCy$.

Cuprous cyanide is insoluble in water, but soluble in cyanide solution, and for this purpose the free cyanide generated at the cathode is required. Supposing we have proper conditions—low current density on both electrodes—enough free cyanide is produced on the cathode in order to keep in solution the cuprous cyanide formed on the anode. As the free cyanide of the cathode is really needed on the anode for dissolving purposes, and as in a still solution the mixing velocity is very low, stirring and warming of the electrolytic bath would expedite this matter considerably and bring the bath very near to an ideal stage. However, warm and agitated solutions require a more careful observation on account of which these two items have not as yet been paid the attention they actually deserve.

If too high a current density is used on the cathode, not all the Na ions act reducing on the sodium copper cyanide, but are partly discharged, forming sodium hydrate and hydrogen in connection with the water of the bath:

$$Na + H_2O = NaOH + H$$

This reaction accounts for the development of hydrogen or gasing at the cathode. It means that less copper is deposited per ampere hour and not sufficient free cyanide formed in order to keep the anode clean. Therefore, the solution necessitates the addition of sodium cyanide, otherwise the anode becomes coated and the passage of the current is interrupted. Too high a current density on the anode leads to the same result; covering of the electrode with an insulating film of cupri-cupro cyanide.

In regard to current density, it must be borne in mind that warmed and agitated solutions can be worked with a higher current density than cold ones, and that a density of approximately 30 amperes per square foot is quite feasible without yielding a burned and blistered deposit.

Another feature which is quite interesting is the amount of metal deposited per ampere hour. In a copper cyanide solution which contains the metal in the cuprous state, the same number of ampere hours should yield twice as much metal as in an acid bath, providing, of course, all the favorable conditions are prevailing, i. e., a strong solution, warmed and agitated, worked with a minimum amount of free cyanide at a low current density. As, however, common plating solutions are worked on nearly the contrary conditions, the relative amount obtained from a cyanide bath is much lower. How much lower depends entirely on the relative conditions, and only one feature should be emphasized, which has been mentioned above: that the more hydrogen develops on the cathode, so much lower is the percentage of the metal deposited per ampere hour. A low current density results in a high weight of the metal deposited per ampere hour, while the deposition is slow. A high current density yields a lower weight proportionately per ampere hour, but consuming less time for a certain weight of metal deposited, resulting in a greater deposition of metal per hour.

Furthermore, cyanide solutions yield a finer, more homogeneous texture and brighter metal film than the acid baths on account of the secondary copper deposition and, because hydrogen may develop more freely on the cathode in such a solution without fear of burning or blistering the deposit.

These few remarks give an idea how complicated the reactions in a plating solution are, and that it requires skill and experience to procure a satisfactory deposit.

The first part of this paper has shown that the constituent which is essential in a copper cyanide bath is the double salt, sodium copper cyanide, consisting of copper cyanide and sodium cyanide, which is easily formed by adding the necessary amount of each chemical to water. A high-grade sodium cyanide has been obtained for quite a number of years, but copper cyanide could only be procured at prices which made its use prohibitive for technical purposes.

For this reason many salts—one might call them subterfuges—have been used which were intended to substitute copper cyanide and form the same when brought together with cyanide solution. One should bear in mind that whatever copper salt is brought together with cyanide solution, the final compound is the double salt, sodium copper cyanide. Another fact which should not be lost sight of is that one chemical can replace another only to the extent of the requisite elements, and that by the reaction of two such salts, always a by-product is formed which contaminates the compound desired.

This is the case with the copper cyanide. Copper carbonate, copper sulphate, copper acetate, cupri-cupro sulphite have been employed in order to form copper cyanide in connection with sodium cyanide and water. That by these reactions an inert by-product consisting of sodium sulphate or sodium sulphite or sodium acetate or sodium carbonate is formed to a high percentage everyone was aware of, but took it for granted as the product necessary, i. e., copper cyanide was not obtainable commercially.

When using copper carbonate, which is really basic copper sulphate containing a small percentage of carbonate, according to the temperature at which it is precipitated, approximately one half pound of inert matter is formed for every pound of copper carbonate, being composed of sulphates and carbonates. By the use of copper acetate, or cupri-cupro sulphite, this inert matter is still further increased, and for each pound of the compounds used, from nine to ten ounces inert salts are produced. These salts accumulate in the bath more and more with every addition of the respective copper salt, and finally yield such a dense solution, which being overloaded with these waste compounds cannot be worked in a satisfactory manner any longer, the plated articles being blistered and the solutions are of necessity discarded.

The reason for this is that a bath of this kind has a relatively low metal concentration and a much higher one of the inert salts. As a rule, the electric current deposits the metal easiest to discharge, which in this case is the alkali metal. Therefore, as the current density increases an excess of hydrogen is generated, which causes burning, and the current output drops considerably.

After considering this crude method of forming copper cyanide one should remember that the copper in a cyanide plating solution is in the cupro stage, while copper carbonate, copper sulphate, copper acetate are cupri salts, and cupri-cupro sulphite is a mixture of both. This means these salts must be first reduced to the cupro state before they are fit for plating. This reduction is executed at the cost of the sodium cyanide which is actually intended for bringing the copper metal into solution only. Further, neutral copper salts as copper acetate, copper sulphate, and cupri sulphite, when brought in contact with cyanide solutions, form cupri cyanide first, which, being an unstable compound, decomposes into cupro cyanide and cyanogen, which latter escapes into the air, and on account of its highly poisonous character is most detrimental to the health of the plater.

Taking into consideration all the disadvantages resulting from the present method for producing a plating solution, every progressive plater should greet with joy the fact that a chemically pure cupro cyanide is now on the market at a price making its use more economical than that of any other copper salt which has been accomplished by new manufacturing methods worked out by the author of this article.

Cupro cyanide contains nothing but the ingredients necessary in a plating solution—copper and cyanogen—so that by dissolving it in cyanide solution no inert, unnecessary products are added. This enables the plater to have perfect control of his solutions at all times, as whenever metal is needed he adds it in the form of copper cyanide, and, when cyanide is needed, sodium cyanide, thus simplifying matters. On account of its high percentage of metal—it contains 70 per cent pure copper, the rest being cyanogen—solutions highly concentrated in metal can be worked at a relatively low specific gravity. This is a further advantage, as a bath low in density is much more easily controlled than a very concentrated one.

Copper cyanide being a cupro salt, does not consume any cyanide in order to be transferred to the cupro stage, and because of its being a cyanide itself it requires less sodium cyanide than any other copper salt to yield the double salt sodium copper cyanide, the essential constituent of a plating solution. This fact points out a more economical method for producing a plating solution. In other words, it saves money. When one buys a metal salt for plating one should not forget that it is not the price of the metal in the salt itself which constitutes the economy of the salt, but the price at which the metal is put into solution as a double cyanide. It is this economy of the copper cyanide combined with its high technical qualities which makes copper cyanide superior to any other plating salt.

The figures in Table I give a comparison of plating solutions produced with different copper salts and are the results of actual tests. The metal contents of the solutions are the same as in Table I.

TABLE 1.

Copper cyanide, 70 per cent copper:		
100 pounds copper cyanide at 42 cents per pound	$42.00	
100 pounds sodium cyanide, 129 per cent, at 22 cents per pound	22.00	
		$64.00
Copper carbonate, 50 per cent copper:		
140 pounds copper carbonate at 14 cents per pound	$19.60	
239 pounds sodium cyanide, 129 per cent, at 22 cents per pound	52.58	
		$72.18
Cupri-Cupro sulphite, termed red copper compound—40 per cent copper:		
175 pounds red copper compound at 30 cents per pound	$52.50	
160 pounds sodium cyanide, 129 per cent, at 22 cents per pound	35.20	
		$87.70
Copper acetate, at per cent copper:		
220 pounds copper acetate at 20 cents per pound	$44.00	
193 pounds sodium cyanide, 129 per cent, at 22 cents per pound	42.46	
		$86.46

After continuous operations for two hours it was found that while the solution made up with copper cyanide remained almost constant, that is, the relative proportions of metals and cyanide were practically the same, the solution made up with the other salts became unbalanced. The anodes coating over requiring further additions of cyanide, showing once more that solutions made up with chemically pure copper cyanide gave maximum efficiency.

As so-called copper carbonate was the most extensively used, I gave this solution special attention and found, after considerable experimenting, that in order to obtain a solution with sufficient free cyanide to obtain a fairly balanced solution the following proportions were necessary:

140 pounds copper carbonate at 14 cents per pound	$19.60	
280 pounds sodium cyanide, 129 per cent, at 22 cents per pound	61.60	
		$81.20

These comparative figures vindicate once more one of the most important rules in chemistry—that pure materials not only give the greatest efficiency, but are the most economical.

In the present time, which is distinguished by the endeavor to obtain an end as simply and as economically as possible, where everything is standardized in order to obtain the best results at the lowest cost, no far-sighted man can dispute the fact that copper cyanide brings this desired standardization to the plating industry, which needs [illegible]

* A paper presented before the Lewis Institute, Chicago, Ill., and published in Metallurgical and Chemical Engineering.

The Formation of Ozone in the Upper Atmosphere—II*

And Its Influence on the Optical Properties of the Sky

By J. N. Pring, D.Sc. University, Manchester

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2052, Page 287, May 1, 1915

It was found that a more valuable yield in the formation of ozone by ultra-violet light is obtained with dry air or oxygen than in the case of the moist gases. This influence of water has been noticed by earlier investigators, and is possibly due to the formation of traces of hydrogen peroxide which is known to react with ozone according to the equation:

$$H_2O_2 + O_3 = H_2O + 2O_2$$

In this series of experiments, air after drying was circulated through the reaction vessel at different pressures. After issuing from the radiation vessel the air was immediately led through the reagent. Measurements were conducted at pressure of 760, 70, and 30 millimeters in the different cases. The same total amount of air was passed in each experiment and exposed to the radiation for the same interval of time (10 minutes). The results showed a great decrease in the formation of ozone with decrease in pressure. Thus, at 760 millimeters pressure the yield amount to 0.1 per cent, and at 30 millimeters to 0.0014 per cent.

Experiments which have been made on the exposure of water to ultra-violet light have indicated that a slight decomposition takes place in accordance with the reaction:

$$2H_2O = H_2O_2 + H_2$$

It has also been stated that when moist air is submitted to the action of ultra-violet light, traces of hydrogen peroxide are formed.

Experiments were made by the writer to detect the formation of hydrogen peroxide by passing 60 liters of moist air through the experimental apparatus during two hours, and leading through a solution of titanic acid in sulphuric acid contained in a small glass spiral washer. No change in color was observed. A comparative test made by taking hydrogen peroxide solution showed that it is possible to detect with certainty the presence of 1×10^{-6} grammes of this compound with the above reagent. In 60 liters of air, this would correspond to a volume of 1.8×10^{-6} per cent. The amount formed under the conditions of the above experiment must therefore be below this value, which is very small compared with the amount of ozone formed. As hydrogen peroxide is decomposed by this last gas, it is doubtful whether any appreciable quantity would be permanently stable in the presence of ozone.

The only method, apart from colorimetric tests with organic reagents, which appears to have been applied hitherto for distinguishing ozone from oxides of nitrogen when at high dilutions is one which consists in passing the gas into liquid air, when ozone dissolves and nitrogen peroxide separates as a solid. This method was applied in experiments made by the writer. A total volume of 66 liters of air, after passing through a concentrated solution of potassium hydroxide and then through sulphuric acid, was led through the reaction vessel, where an arc was formed continuously, and was then passed into liquid air. A period of six hours was taken for the passage of the total volume. After this time, a small quantity of white solid, which appeared to be mainly ice, had collected in the liquid air. On separating by filtration through fine cloth, and then collecting the gas evolved on evaporation in a gasometer over mercury, about a liter of gas was obtained. This did not give any coloration with tetra-methyl base paper, nor, on passing the whole through acidified potassium iodide solution, was any iodine liberated.

Though it cannot finally be stated from these experiments that no formation of oxides of nitrogen or hydrogen peroxide occurs through the influence of ultra-violet light, yet it is shown that the quantity obtained is negligibly small when compared with the ozone.

The experiments show clearly that in the higher atmosphere the conditions are present for the formation of a considerable quantity of ozone, but the data are not available for calculating the magnitude of this equilibrium value.

It may be inferred that as the light of the small wave-length necessary for the formation of ozone cannot penetrate any large distance into the atmosphere, this formation of ozone must be confined to the very high layers of the atmosphere.

THE DISTRIBUTION OF OZONE IN THE ATMOSPHERE AT HIGH ALTITUDES.

The sounding vessel which was used to enable the application of these measurements to atmospheric determinations was devised so as to be suitable for use in mountain districts, and also for attaching to sounding balloons.

An approximate calibration of the volume of air circulated was made by means of the assumption that this amount is arithmetically proportional to the velocity of the wind. A measurement was then made by placing some pure benzine in the vessel, and after exposing for definite intervals to a wind of known velocity, noticing the loss in weight. Knowing the vapor pressure of benzine at the prevailing temperature, it was possible to calculate the volume of air passed by assuming that evaporation of the benzine would take place to the saturation point. The average of a number of these determinations showed that when the apparatus was exposed to a wind for an interval, during which a horizontal flow of air of one mile occurred, the volume circulated through the vessel corresponded to 5.12 liters.

Estimations of ozone, extending over several days, were made in Switzerland, first at a point near Scheidegg, (Wengern Alps), at an altitude of 6,970 feet, and then at a point near the Jungfraujoch, of 11,080 feet altitude.

During these measurements, tests were made for hydrogen peroxide by exposing titanic acid solution in an apparatus similar to that used for the ozone estimation. The color of this reagent remained quite unchanged after exposing for two days at the different altitudes and under different conditions of weather, thus showing that there was no appreciable quantity of hydrogen peroxide in the atmosphere. It was noticed, on the other hand, that freshly fallen snow or hail gave a very marked coloration with the reagent. It is hoped later to conduct tests with glacier water, as this would be expected to retain the hydrogen peroxide associated with the snow.

In the estimations of ozone, made by means of potassium iodide, it was found that in no case was any potassium iodate formed. As pointed out above, this shows the absence of any appreciable quantity of oxides of nitrogen.

The results of the estimations of ozone showed a mean volume per unit volume of air at 6,970 feet of 2.56×10^{-6}; and at 11,600 feet, 4.7×10^{-6}.

In order to obtain some idea of the amount of ozone in the higher regions of the atmosphere, use was made of the sounding balloons which are used in meteorological investigations at the Manchester University. These balloons, with the instruments attached, rise to an average height of about ten miles, and then burst. The deflated skin retards the rate of fall of the instruments to the ground. A knowledge of the height attained and the temperature is obtained by a recording baro- and thermograph. The reaction vessel for the ozone tests was of the same form as used in the previous experiments, and was suspended vertically from the balloon together with the other instruments.

A rough calculation of the amount of air which would pass through the vessel during an ascent and descent was made, and it was seen that the exposure of the vessel to a horizontal flow of air of one mile caused the passage of 5.12 liters. Expressing in centimeters, this gives for a displacement of 1 centimeter 0.032 cubic centimeters.

On the assumption that the volume circulated is proportional to the displacement through the air, it follows that during an ascent and descent, the mass of air passed through in grammes is given by $2\ (p - p_1) \times 13.6 \times 0.032$, or $0.87\ (p - p_1)$, where p is the atmospheric pressure in centimeters of mercury at ground level, p_1 that at the highest level reached, and 13.6 the density of mercury. The volume circulated in liters (measured at N.T.P.) is therefore $0.675\ (p - p_1)$.

At a height of about 6,000 meters the temperature is always below the freezing point of the reagent (—24 degrees), so that reaction must then take place with the solid. It was seen above that under these conditions the method applied did not enable a distinction between ozone and oxides of nitrogen. However, in all measurements made up to 3,600 meters, it was found that neither this gas nor hydrogen peroxide were present in any appreciable quantity. Nitrogen peroxide is of course quite stable at ordinary temperatures, and until dissolved by atmospheric water as nitric acid, any gas formed at high altitudes would remain undecomposed.

By considering the results obtained together with those made on ground level at altitudes up to 3.5 kilometers, the conclusion may be drawn that there is no appreciable amount of hydrogen peroxide in the higher atmosphere, but that there is a considerable quantity of ozone.

The mean values of ozone estimated in the measurements made in the Alps were 2.5×10^{-6} in one volume of air at 2.5 kilometers altitude, and 4.7×10^{-6} parts at 3.5 kilometers. In the measurements made with the balloons above Manchester, the mean volume of ozone between ground level and altitudes up to 20 kilometers gave a value of 2.1×10^{-6}. Even after allowing for the absence of this gas at lower altitudes, the measurements, though only approximate, indicate that there is no very large increase in the amount of ozone at altitudes between 4 and 20 kilometers. However, since at this last height the pressure of the atmosphere is still about 4 centimeters, the amount of light of wave length below 200 $\mu\mu$, which is necessary to form ozone, would be very small. The probability thus still remains that above this elevation a largely increased content of ozone prevails.

THE INFLUENCE OF OZONE ON THE NATURE OF LIGHT FROM THE SKY.

The results in the above experiments of the approximate determinations of the quantity of ozone in the higher atmosphere supply data which enabled measurements to be made in the laboratory of the depth of color given by this amount of ozone.

For this experiment, a glass tube of 2.8 meters length and 4 centimeters diameter was taken. The walls were provided with side tubes, one near each end, to enable the passage of the ozonized gas through the tube. The two ends of the main tube were covered by thin plates of glass, which were cemented by sodium silicate solution so as to make an air-tight connection. The outside of the tube was wrapped with black paper, and a white paper disk placed over one of the end plates. On illuminating this by daylight and viewing the transmitted light through the other end, the intensity of coloration produced on admitting ozone of known concentration could be observed.

The results given in the table below record the observations made with the tube when filled with oxygen containing different concentrations of ozone. The thickness of the layer of pure gas which is equivalent to this concentration is also given.

Percentage Concentration of Ozone in Oxygen	Equivalent Thickness of Layer of Pure Ozone.	Color Observed
0.20	0.55 centimeters.	Color uncertain.
0.36	1.0 "	Faint bluish green.
1.7	4.7 "	Distinct blue color.
2.8	7.8 "	Indigo or steel blue.

It is difficult to compare the color of the gas in a tube of the above nature with that of the sky on account of a large influence exerted by the nature of the illumination.

The above amounts of ozone can be compared with those found in the atmosphere. Taking the amount of this gas found in the Alps at an altitude of 3.6 kilometers as the mean concentration throughout the atmosphere, and allowing 8,350 meters as the height to which the atmosphere would extent if at N.T.P., this concentration of ozone in a vertical section of the atmosphere is equivalent to a layer of the pure gas of a thickness of 4.2 centimeters at N.T.P. On comparing this with the observations made on the color of ozone in a glass tube, it is seen that light which has been transmitted through a layer of gas of this thickness possesses a distinct blue color. In the case of atmospheric ozone at very high altitudes it is probable that the amount of ozone increases and there is also the possibility that the blue or violet color is intensified in this case on account of fluorescence by ultra-violet light from the sun.

With regard to the values obtained in the estimation of ozone at high altitudes, on account of incomplete absorption by the reagent, the experimental error of the measurements would be expected to give too low a value. On account of this and the probability of a large increase in the amount of ozone at altitudes above 20 kilometers, the results of these measurements indicate that ozone is an important factor in determining the optical properties of the atmosphere and the color of the sky.

* [illegible] published in Science Progress.

High-speed Bullets and Dumdums

It is unfortunate that the disposition of a bullet is not always as benign as its appearance. Its failure to live up to its mild looks is responsible to a great extent for the dumdum charges that have been fired back and forth between the opposing forces in Europe only a little less frequently than the huge shells.

Queerly enough the mildest looking bullet among those used by the Germans and the Allies is the one with the most fiendish traits. This, the spitzer or pencil-pointed modern bullet, fired in the German Mauser the French Lebel and to some extent in the British Lee Enfield is apparently shaped to punch holes in soldiers with the minimum of pain and annoyance to said soldiers. The point looks as if they had put the old style blunt nose bullet in to a pencil sharpener and finely sharpened the point.

So kind hearted does this sharp nose missile appear that various theoretical parties about the country al ou ced in 1o 1ub ic 1 in s tl at the sole reason for its adoption was to be as humane in shooting the other fellows as ir sta s would allow. Unhappily this explanation for the sharp point lacks a minor virtue—that of being true. Experiments by the Germans in 1905 evolved the fact, known fifty years before but forgotten that putting a very sharp point on a bullet cut down air resistance, as a sharp bow on a boat cuts down water resistance. In turn, this allowed a lighter bullet to overcome air pressure and therefore to hold its speed as well as a heavier bullet of the old type. In turn this allowed of higher speeds, because the bullet was lighter and pressure and kick were less, and the higher speeds gave flatter flight of bullet and much increased danger spaces through this flat flight. So came the spitzer.

The French and the Swiss went the Germans one better and tapered the stern of their bullets also making them a true boat shape, that the air might flow back around them and not drag.

So instead of advancing the cause of humanity by adopting painless keen cutting bullets, the nations taking up the spitzer sought nothing more merciful than hitting still more men on the other side of the argument.

And worse and more of it, the sharp point bullet developed a wounding effect far greater than that of the old, long blunt nose bullet. The latter practically never did aught but whip through cleanly never tumbling or upsetting or lacerating or smashing bones. The new bullet with the center of gravity far back and with the point very light and easily deflected just as is the front wheel of a bicycle, developed an alarming tendency to turn sideways, or to swap ends like a skidding automobile or to spin on its base like a wabbling top. Any one of the three wrecked tissue and inflicted savage wounds akin to the soft point bullet used for game shooting and by the British for use on savages.

Colonel Roosevelt in his African trip of 1909 was the first truly prominent personage to call to public attention the deceiving nature of a bullet that promised on the face of it, to make war more attractive. He took with him to East Africa a sporting model of the Government New Springfield and for this he took both the old, blunt nose bullet, with soft nose for game shooting and some of the regular Government cartridges with the 150-grain spitzer bullet, just as issued to troops. After a few weeks lo and behold he abandoned the old soft nose ammunition and used the spitzer Government stuff exclusively for the good reason that it was more deadly! And, mark you more deadly than soft nose bullets specially designed to expand and break up and inflict horrible founds.

Then in 1910 Stewart Edward White the noted novelist, sought the East African country taking with him the duplicate of the battery of the famous Colonel, including some of the soft nose old type bullets for his New Springfield and some regular spitzer 165-grain bullets full jacketed, for the same rifle.

Like his predecessor he speedily abandoned the heavier longer blunt-nose and soft-point bullets, for the full jacketed spitzer bullets as used by many of the civilized nations. On this first trip he killed over two hundred head of big game. He actually hit 186 head with the Springfield army rifle, and he bagged 170 of these animals, three of those wounded and escaping, being animals going to ground like jackals. Thus practically no animal hit got away wounded and the deadliness of this bullet was proved superior to even the specially designed capped English big game bullets, made to break up and inflict all the damage possible on flesh.

Some years ago the Russian Red Cross complained to the Russian Minister of War against the spitzer bullet then just adopted by the Germans and Austrians alleging that it had been proved beyond doubt that this bullet inflicted needlessly severe wounds by its tipping and wild flight through tissue. Without doubt the high speed of the bullet aids this effect. Without doubt at the longer ranges, 800 yards or more, where the bullet has lost half of its original speed, this effect is not to be found. When you consider a bullet traveling with a velocity of close to 2,900 feet a second and spinning at the rate of over 3 000 revolutions per second it is easy to understand that if it got to spinning widely on its rear end instead of truly on its axis, the effects would be those of a far larger and more severe bullet.

The term dumdum, used glibly by newspaper correspondents, is not at all applicable to the bullets that may have been deformed or partly sawed through by some misguided people on either side. In the early days of the .303 bore British Lee-Metford, among the earliest of the small bore, high speed rifles, the British found that the small full jacket bullets would not stop infuriated or fanatical Indian hillmen. The bullets romped right through, delivering little shock except when striking vital parts and the fanatics hit did not go down. They might die in sixty seconds but if this time were enough for them to get to the British line and use their knives, the time was too long. So the little British East Indian arsenal of Dum Dum was given the job of changing around these 0 30 caliber bullets to inflict great shock and stop a charging man.

They did this by cutting away the jacket of German silver at the point, exposing the leaden core. The impact on the body of a man would cause the lead to flatten out or mushroom and the jacket to strip or rip back giving a missile with a great shock giving power. This was the father of all modern soft-nose game-shooting bullets. The original dumdum was changed about a bit, being made hollow nosed, the jacket being cut away at the point, and the core having a hole bored down in it to cause more ready expansion. This took its place in the li e of British cartridges being known as the Mark IV. While agreements among the civilized powers forbade the use of any bullet, altered or designed to produce expanding or explosive effects, the heathen were not represented and it was so much the worse for the heathen.

These Mark IV bullets were used on the hillmen of India for years—and maybe yet—and were later used on the dervishes and on the Matabeles of Africa.

But the modern spitzer at its still higher velocities and its unsteady performance in tissue gives results that are more frightful than any dumdum. Were this not true, then the African sportsmen never would have abandoned heavy soft-nose bullets for a lighter full jacket bullet that could not possibly break up or expand. *Ergo* if the Allies did turn to dumdum bullets they would very probably turn to missiles more merciful and less destructive than the perfectly civilized and authorized sharp point missiles.

It is true that the spitzer bullet does not always go through the same performance. Doubtless this is due to the range. Game is killed under 500 yards most of it under 200. What the bullet might do at this range it might not do at all at 800 yards or farther. So to draw a parallel between our game shooting experience and war we must also consider the ranges used. This is not to say that the greater number of men hit are not hit at practically game-shooting ranges, but it is to explain why men may suffer severe wounds, or merely clean punctures from the self same class of bullets.

National Standard Hose Couplings and Fittings for Public Fire Service*

The movement for the adoption of standard fire-hose couplings dates from the great Boston fire of 1872 which showed the impossibility of the fire departments of adjacent towns acting in unison when provided with the diverse sizes of hose fittings then prevailing.

The matter was taken up at the first convention of fire engineers in 1873 and was discussed at various conventions in succeeding years. The resolutions gradually became more definite although little was accomplished toward bringing about the desired changes until the agitation received a new impetus from the Baltimore fire in 1904 when neither the Washington Philadelphia, nor New York fire engines on their arrival could make connections with the local fire hydrants.

This condition led the Merchants & Miners Transportation Company in April, 1904 to request the secretary of the Department of Commerce and Labor to investigate the subject of fire-hose couplings. The secretary referred the matter to the Bureau of Standards and in the investigation which followed, it was found that there was a great diversity in sizes and threads of couplings throughout the United States. It was evident that considerable expense would be involved in changing from one standard to another and therefore, at the conference of the committees of the National Fire Protection Association and American Water Works Association, held in New York city, April 24th, 1905, the Bureau of Standards suggested that either the thread most extensively used or that thread which possessed the greatest advantages in other respects, might be adopted. Following the latter advice, the conference resolved that 7½ threads per inch should be recommended for 2½-inch fire-hose couplings. This thread was not regarded as necessarily an ideal standard, but was considered as a practicable basis for unification under prevailing conditions.

At the annual convention of the International Association of Fire Engineers at Duluth in 1905 this standard was adopted after lengthy discussion and at Dallas in 1906 the convention re-affirmed the action taken at Duluth and made its record complete by adopting the national standard specifications covering couplings of 3 and 3½ inches inside diameter each to have 6 threads to the inch and a 4½-inch coupling having 4 threads to the inch.

Since then a dozen large organizations have adopted the national standard. The report of the committee of the American Society of Mechanical Engineers, adopted December 3d, 1913 treats its present status in a very clear and comprehensive manner with suggestions for converting non-standard couplings for serviceable interchange with the national standard. Up to 1914 the national standard had been put into service in 287 towns and cities either as new equipment or by adaptation of non-standard couplings to interchange with the standard.

* Bureau of Standard Circular No. 50.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK SATURDAY MAY 8th 1915

Published weekly by Munn & Company Incorporated
Charles Allen Munn President Frederick Converse Beach Secretary Orson D Munn Treasurer
all at 233 Broadway New York

Entered at Post Office of New York N Y as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year	$5 00
Scientific American (established 1845)	3.00
American Homes and Gardens	3.00

The combined subscription rates and rates to foreign countries, including Canada will be furnished upon application

Remit by postal or express money order bank draft or check

Munn & Co , Inc., 233 Broadway, New York

The purpose of this supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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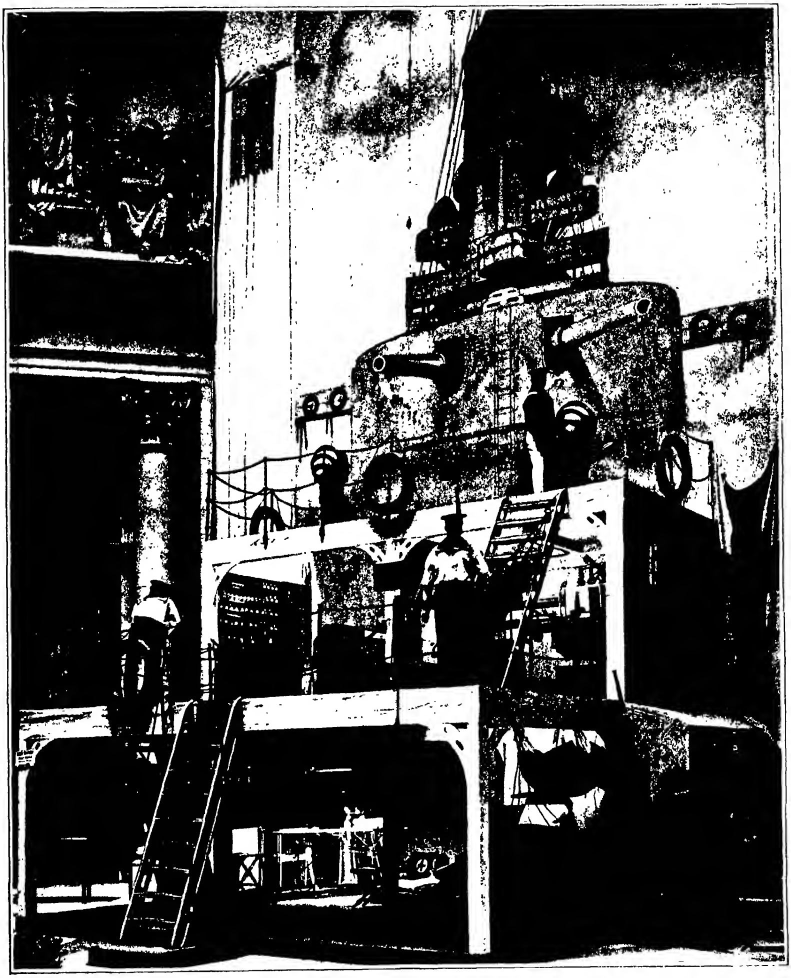
SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX
NUMBER 2054

NEW YORK, MAY 15, 1915

10 CENTS A COPY
$5.00 A YEAR



Scene at the sanitary exhibition at Berlin.

FULL SIZE MODEL OF A HOSPITAL ON A MAN-OF-WAR.—[See page 316.]

Pathology of Mental Disorders—I*

Modern Aspects of Certain Problems

By Edwin Goodall, M D., Lond., B.S., F.R.C P., Lond.

When I was honored with an invitation to deliver these lectures before the college I deemed it a duty to make it clear that it would not, in my judgment be possible for any one whose work lay in the domain of psychiatry to bring before you at the present time an array of substantial results based upon scientific research such as would for a moment compare with the results available for a general pathologist a bacteriologist or a worker in the general domain of pathological chemistry This disability is doubtless recognized by those whom I have the honor to address briefly It depends firstly upon the inherent difficulties of the problems of the pathology of mental disorders and secondly upon the deplorable separation of psychiatry from the other branches of medicine in this country more especially a separation which I am glad to believe is nearing its termination In view of the comparative paucity of facts available for the purposes of my theme it is necessary that my range should be somewhat wide and I shall have broadly speaking to deal with the results of pathological and bacteriological research with problems of metabolism with chemical and serological observations and with certain therapeutic measures based upon observations in clinical pathology

MORBID HISTOLOGY IN MENTAL DISEASE

Already 20 years ago dissatisfaction with the results of histological research was expressed and the advent of the worker in the field of biochemistry was desired The histological work of those who had gone before was recognized as indispensable, while we were not so foolish as to believe that it was complete it was nevertheless felt that the knowledge we possessed of the morbid histology of the brain in mental disease was not mean and that the time had arrived when following the rational course we should search for the pathological factors which had expressed themselves in the modes with which we were familiar There remained and there still remains the problem as to the degree of responsibility of the histological lesions for some of the symptoms perhaps characteristic symptoms of this or that kind of insanity by virtue of specific localisation of lesions in specific kinds of insanity

At the present time we have to record that there are in most cases of mental disease uncharacteristic brain changes but, largely owing to the powerful impetus given to histological research by the work of Alzheimer and Nissl and their pupils characteristic brain changes have been shown in mental disease associated with syphilis in the progressive dementia which accompanies some cases of arterio-sclerosis and in senile dementia On the other hand the histological lesions found in the following clinical kinds of insanity are not characteristic the kinds grouped under the term dementia præcox the alcoholic insanities so-called manic depressive insanity acute delirious mania insanity with epilepsy though it be granted that in the last mentioned instance a diffuse cerebral gliosis is found in cases dying from intercurrent disease after years of the malady There is no evidence of characteristic localisation of the lesions found in the brain in the psychoses either as regards the brain as a whole or as regards layers of the cortex cerebri or constituents of the cortex unless the involvement of the mesodermal elements in the psychoses primarily due to syphilis or associated with trypanosomiasis are so considered

THE DEMENTIA PRÆCOX GROUP OF CASES

I am not I think justified in detaining you with observations upon morbid histology in mental diseases further than is necessitated by a reference to the particular cases of respectively the dementia præcox group and dementia paralytica In studying the pathological anatomy of the cases nowadays grouped under the name 'dementia præcox' we are faced with the difficulty that death seldom occurs in an early stage of the disease and when it does it is due to intercurrent maladies especially tuberculosis which may themselves be partially responsible for the morbid appearances The disease is not due to lethal causes Incidentally the same is true of other psychoses such as the systematised delusional disorders and even manic-depressive insanity as a rule Zingerle[1] rightly points out that one must further discount appearances which may well be referable to mere congenital defect of development. There being no characteristic anatomical picture for the disorder as a whole, its subdivision, clinically, into three groups obtains of course no support from the standpoint of pathological anatomy The points to be noted for verification from the observations made up to the present are that, at any rate for the variety mentioned the lesions—of the individual elements—which are in no way peculiar, but are those found in many acute and recent mental disorders (degenerative conditions as shown by modern methods in nerve and glia cells) are found throughout the brain, the cerebellum and the basal ganglia, that they are especially pronounced in the deeper layers of the cortex cerebri, that they concern the ectodermal elements (degeneration) especially and the mesodermal to a much less extent (absence of inflammation) Should these observations be confirmed they would afford a means of distinguishing anatomically between this clinical variety of dementia præcox and such diseases as dementia paralytica insanity due to lues cerebri, to arterio-sclerosis and to chronic alcoholism in which vascular and perivascular changes are marked If confirmed they would point to the conclusion that maladies which are associated with lesions so diverse must be unlike in pathogenesis

DEMENTIA PARALYTICA

In regard to the morbid anatomy of dementia paralytica it is admitted that while none of the macroscopic or microscopic lesions is pathognomonic, these together form a whole which is characteristic To the naked eye the combination of the indications of long standing lepto meningitis especially pronounced over the fronto-parietal area of cortical erosions of wasting of the pre-frontal gyri and granularity of the ependyma of the ventricles is characteristic Histologically the diffuse nature of the infiltration by products of inflammation of the vessel walls traceable throughout the vessels including the finest the tendency of the infiltration to keep to the vessel walls and perivascular area the superabundance of plasma cells these are characteristic Some might claim that the multiplicity the gravity and the widespread distribution of all the lesions throughout the nervous system are characteristic.

Lesions in Dementia Paralytica and Cerebral Lues

One has selected the frontal gyri almost as matter of course as the most likely ones in which to find the spirochæta pallida and recent writers appear to find the organism with less difficulty in them than elsewhere Having regard to the fact that the morbid histology of the brain in dementia paralytica, and in diffuse cerebral lues I think I may also say, was—if we except plasma cells and rod cells—well known to pathologists in 1892 it is somewhat surprising to me that I cannot remember that anyone then pointed out the difficulty of differentiating between these two conditions by histological examination The failure to recognize or at any rate to lay stress upon the resemblance between these two histological pictures I ascribe to the absence of co-ordination between workers in psychiatry and neurology and to the fact that the importance of syphilis in the pathogenesis of dementia paralytica was not then recognised It was not I think until by patient clinical observation and inquiry into the histories of cases evidence of syphilis was found in a large proportion that such evidence was sought for by the methods of morbid histology and no doubt interest in this inquiry was further promoted by the results obtained by the application of the method of complement-deviation to the serum and cerebro spinal fluid of general paralytics

Sträussler[2] (1911 and 1912) described six cases in which syphilitic lesions—such as meningitis and miliary gummata—coexisted with changes typical of dementia paralytica I cite the above work as indicating how, in recent times and in the light of better knowledge of the pathology of dementia paralytica, a close relationship has been found between the lesions of diffuse cerebral lues and of so-called metasyphilitic disease of the brain The importance of the plasma cells in the latter has been exaggerated I have already alluded to the extraordinary abundance of these elements in the brain of the general paralytic, and this appears to be a characteristic of dementia paralytica, I believe also of sleeping sickness. But they are not peculiar to any special disease, they have been described in cerebral lues, in non-specific encephalitis, and in non-specific foci of inflammation in the central nervous system[3,4] They appear to constitute a mode of reaction to different toxic agents.

Relations of Dementia Paralytica and Cerebral Syphilis

The demonstration of the existence in certain cases of diffuse cerebral lues and dementia paralytica of the same cerebral lesions and the demonstration of mixed histological lesions illustrating both conditions, in the same brain, leads to the suggestion that dementia paralytica is merely an unusually late manifestation of syphilis of the brain. The number of syphilitics who develop tertiary lesions in the brain is rare, according to Henschen,[5] of 754 only 17 86 per cent do so. The number developing dementia paralytica is still rarer, statistics place the incidence at 4-5 per cent. As to development of dementia paralytica in cases of cerebro-spinal lues, Mattauschek and Pilcz[6] found that of 116 cases of the latter condition only 2 got the former This observation is particularly interesting It is in keeping with the clinical, anatomical, and histological evidence furnished by typical cases of dementia paralytica which demarcates the condition from cerebral lues To this has to be added the evidence furnished by the studies in the metabolism of nervous and mental disorders which have been made in quite recent times which, although doubtless in need of confirmation and amplification go to show that in dementia paralytica there are well marked disturbances which are not found in lues cerebri, so that some additional factor would appear to be operative in the former case Nevertheless, atypical cases of dementia paralytica are not few, and in these it does not seem possible, whether by clinical, serological anatomical, or histological means, to differentiate the condition from diffuse cerebral lues

Neuropathic Inheritance in General Paralysis

Those of us who have reached a certain age will recall that as students we were taught that this disease occurred in persons in whom as a rule no neuropathic inheritance could be found Not only had their own lives been usually exemplary, with the possible exception of lapses in a remote youth, but they came from a sound stock Naecke,[7] however, in numerous publications based upon most painstaking and prolonged investigations, has shown that hereditary predisposition to nervous disease is very considerable in dementia paralytica, scarcely less so than in other kinds of insanity and that such certainly exists in 50 per cent of cases Schroeder[8] finds neuropathic inheritance, and evidence of neuropathic disposition in the patient himself in 77 8 per cent of cases. The observation of Schroeder as to evidence furnished by the patient himself points to the importance of seeking for evidence of defective development as furnished by a study of the so-called stigmata of degeneration, in the adult insane In a paper published in 1899[9] I dwelt upon this subject and submitted the scheme of examination I had been following, but in carrying out such inquiry we are met with the difficulty of obtaining control observations upon normal individuals of the same age-periods, social class and district as the patients Such controls would require to be carried out with the dead as well as the living subject, for there are of course anomalies of formation of internal as well as of external organs (internal and external stigmata) The above are no light hindrances. Observers are exceedingly few who have grappled with this difficulty, pre-eminent among them is Naecke He asserts that external and internal stigmata are more frequent, grave, and widespread in general paralytics than in normal persons, he finds that in the former, in so far as the brain is concerned, microgyria, underdsized frontal convolutions (especially), and the rarer variations or anomalies of the gyri and sulci, which especially indicate arrest of development, appear much oftener than in normal persons. The general paralytic's brain he regards as deficient ab ovo Naecke quotes Vogt, who refers to observations by Roudonis of Florence, from which it appears that there is in the juvenile general paralytics

* Abstracts from a lecture delivered before the Royal College of Physicians of London

[1] Zingerle Monatsschrift für Psychiatrie und Neurologie, 1910 Hefte 4

[2] Sträussler Monatsschrift für Neurologie und Psychiatrie, 29, 1911 Zeitschrift für die gesamte Neurologie und Psychiatrie, Originale 12, 1912.

[3] Klippel and Lhermitte L'Encéphale, June 24th, 1909

[4] Mohr Allgemeine Zeitschrift für Psychiatrie, Band lxvi.

[5] Cited by Allers Zeitschrift für die gesamte Neurologie und Psychiatrie, Band xviii., Hefte 1 and 2, 1913

[6] Cited by Allers Zeitschrift für die gesamte Neurologie und Psychiatrie, Band xviii., Hefte 1 and 2, 1913

[7] Naecke Allgemeine Zeitschrift für Psychiatrie, Bände lv., lviii., lxv., Neurologisches Centralblatt, 1908, No. 22; Allgemeine Zeitschrift für Psychiatrie, 1900, No. 35; Zeitschrift für die gesamte Neurologie und Psychiatrie, Originale, 1 and 2, 1910.

[8] Schroeder: Neurologisches Centralblatt, June, 1913.

[9] Goodall: The Lancet, July 15th, 1899, p. 146.

examined by him a cerebral cortex which in various details is immature (embryonal layer-formation, imperfect cells, anomalies of the medullated substance, etc.). Neuro-psychopathic inheritance in dementia paralytica is regarded by Junius and Arndt[19] as the next most important factor to syphilis.

Comparison of Sleeping Sickness and General Paralysis.

The fact that syphilis preceded general paralysis having been established, it was highly suggestive when attention was drawn to the fact that sleeping sickness—a condition having a remarkable clinical and pathological likeness to general paralysis—followed upon trypanosomiasis, a disease with points of resemblance to syphilis, as is well brought out by Browning and McKenzie.[20] According to Schaudinn the spirochæta pallida stands near the trypanosome in the protozoal group. It is to be noted that trypanosomiasis does not lead to sleeping sickness in all cases by any means; I do not know in what proportion the sequence occurs, but the point is of interest by analogy with the parallel circumstance in regard to syphilis and dementia paralytica. The curability of trypanosome fever and of syphilis contrasts with the incurability, at present, of sleeping sickness (the dementia of trypanosomiasis) and dementia paralytica.

In marked contradistinction to the infrequency with which the treponema is still found in dementia paralytica is the frequency with which the trypanosome was found by Vix in sleeping sickness (65 out of 70 cases, in the blood or cerebro-spinal fluid). Another distinction is that the proclivity of the frontal lobes to suffer in the former disease is not noticeable in the latter. The trypanosomiasis recently described as frequent in Brazil, otherwise known as Chagas' di sease, and due to the T. Cruzi (which is found in all regions of the brain in cases which run a chronic course and become demented) appears likewise to result sometimes in a condition resembling dementia paralytica.

Evidence of Toxic Process in Dementia Paralytica.

Cases of pellagra are on record[21] in which the psychical symptoms and neurological signs (reflexes, pupillary condition, speech) have resembled those of dementia paralytica, but the morbid anatomy of the brain was not inquired into. But before the evidence of antecedent syphilis was available, and long before the points of resemblance between sleeping sickness and dementia paralytica were known, the clinical and pathological evidence of the toxic nature of the morbid process in dementia paralytica was recognized as strong. From the clinical standpoint there are the exacerbations and remissions, very suggestive of recrudescence and quiescence of a toxic process; the variations of temperature, of unknown causation, and only found when the temperature is taken several times daily over long periods; and the seizures. The latter are comparable to those observed in uræmia and eclampsia. There is the polynucleosis of the blood in connection with exacerbations, and some would add that of the cerebro-spinal fluid. As regards morbid histology, the well-known changes in the walls of the cerebro-spinal vessels, in the perivascular and interstitial tissues of the central nervous system, are suggestive of a toxic process. But these changes, including infiltration of these tissues with lymphocytes and plasma cells, are not limited to the nervous system.

Spirochætes in the Brain Cortex in Dementia Paralytica.

Our knowledge may be summarized thus in regard to the demonstration in sections and films of the brain cortex.

Noguchi's statistics,[22] as published up to July, 1913, dealt with 200 cases; the organisms were found in nearly 25 per cent in sections. Marinesco and Minea[23] found them, (apparently in sections) in 1 case out of 26—nearly 4 per cent; Levaditi, Marie, Bankowski,[24] in sections, in 3 out of 32—10 per cent. By the fresh film method of Fontana-Tribondeau (silver impregnation, after fixing and mordanting), Loeffler's fresh method, and dark-ground illumination they found the organism in 8 out of 9 cases—88.8 per cent. It is to be noted that the last-mentioned authors obtained these satisfactory results in cases which died in from 1 to 14 months after the diagnosis of the malady—that is, in rapidly progressing cases; furthermore, 8 of the 9 died from seizures. In Noguchi's original series rather more than one half of the cases averaged only 17 months in duration. In the case figured by Uhlenhuth and Mulzer, in their "Atlas of Experimental Syphilis in Rabbits," a syphiloma was produced in the testicle by inoculation of brain material from a particularly early case of general paralysis. Scholberg and Goodall examined films prepared from the cortex of the frontal lobe on the morning upon which death occurred in 8 cases, all of them examples of long standing disease (dementia paralytica), the dark-ground, Indian ink, and Fontana-Tribondeau methods being used. In none were undoubted spirochætes found, although doubtful instances occurred in two of the cases. From the foregoing it appears that statements still vary considerably as to the frequency with which the spirochæte has been demonstrated in the cortex cerebri in dementia paralytica.

Changes in the nervous system as a result of experimental inoculation with material containing spirochæta pallida.—Although many more investigations are required, with parallel observations upon other tissues, it is obvious from those recorded by Jakob and Weygandt[25] and a few others that the entire nervous system is involved in changes of an inflammatory nature in consequence of inoculation of the spirochæte; the morbid process involving primarily the membranes and blood-vessels, with production of inflammatory foci, suggestive of gummata, of abundance of lymphocytes, plasma- and rod-cells, with gliaproliferation, and the like conditions, such as we are familiar with in sections of the general paralytic's brain.

Diphtheroid Organs.

There are bacteria found in the tissues of general paralytics which it is easy to dismiss a merely capable of inducing secondary inflammation, but I do not think we are yet are sufficiently acquainted with them to assert as much as this. While unable to follow Ford Robertson in his views as to the causative rôle in dementia paralytica of certain "diphtheroid" organisms described by him, I think it desirable that his results should be borne in mind, and not unlikely that the record of results obtained by the study of other bacteria will accrue to be collated with his. The diphteroid organisms described by Ford Robertson[26] have been shown by him in large numbers, and associated with inflammatory changes of the parts involved, invading the walls of the respiratory (including the nasopharyngeal), alimentary, and genito-urinary tracts, in the foci of catarrhal pneumonia which occur in cases dying in "congestive" seizures, in the walls of the cerebral vessels, in the perineural sheath of the trigeminus, in the pia-arachnoid, in the blood, and the centrifugalized deposit of the cerebro-spinal fluid, in the urine—in all these fluids especially after seizures. They invade the lymphatics of the parts involved. The mucosa of the tracts involved and the subjacent tissues present evidence of chronic inflammation. The bacilli have been cultivated from the blood, urine, and cerebro-spinal fluid. Rats and a goat inoculated with them from a case of general paralysis developed paretic symptoms, and histologically lesions closely resembling those of early general paralysis were found.

At this point I would refer to an interesting statement of Cerletti,[27] to the effect that in connection with "cimurro" (glanders) in dogs, months after recovery from the catarrhal infection, a demented state slowly supervenes, with ultimate cachexia and death. It appears that some veterinary surgeons regard this condition as the same as dementia paralytica. In it Cerletti has found a chronic encephalitis with diffuse lymphocytic and plasma-cell infiltration; and the cortical lesions he considers like those of dementia paralytica.

The Question of Lues Nervosa.

Since the demonstration of the spirochæte in the brain of general paralytics attention has been mainly focussed upon a particular problem in the pathology of the disease—namely, its relations to syphilis. The rarity of the disease in syphilitics, the mild nature of the antecedent syphilis in general paralytics, the clinical and pathological peculiarities of general paralysis, the difficulties surrounding the detection and culture of the spirochæte in general paralysis, the difficulty of inoculating animals with this organism as compared with the organism of ordinary syphilis, these and the like considerations have prompted the suggestion of a spirochæte with special affinity for the nervous system, the possibility, in other words, of a *lues nervosa*. The soil is often not a normal one, there being, as has been said above, evidence of neuropathic inheritance in a considerable proportion of general paralytics.

(*To be continued.*)

[19] Junius and Arndt: Archiv für Psychiatrie und Nervenkrankheiten, Band xliv., Heft 1.

[20] Browning and McKenzie: Review of Neurology and Psychiatry, vol. vii., 1909.

[21] Mondgrant: Jahresbericht für Neurologie und Psychiatrie, vol. xvi., 1912.

[22] Noguchi's figures cited in Annales de l'Institut Pasteur; Tome xxvii., No. 7, 1913.

[23] Marinesco and Minea: Bulletin de l'Académie de Médecine, No. 12, 1913.

[24] Levaditi, etc.: Annales de l'Institut Pasteur; Tome xxvii., No. 7, 1913.

[25] Jakob and Weygandt: Münchener Medicinische Wochenschrift, No. 37, 1913.

[26] Ford Robertson: Journal of Mental Science, April, 1906; Ford Robertson and McRae; Ibid., July, 1907; Review of Neurology and Psychology, vol. vii., 1909, etc.

[27] Cerletti: Rivista Sperimentale di Freniatria, vol. xxxviii., No. 4, 1913.

Electrical Engineering and Race Progress

To what extent has the science of the electrical engineer contributed to human development by improving human progress and efficiency?

The answer to this fascinating question may be found in the very thoughtful inaugural address which Dr. A. H. Railing gave recently as chairman of the Birmingham Local Section of the Institution of Electrical Engineers. As is pointed out in the address, electrical engineering is a power working for the forces of civilization if it enables us to make better use of matter, either by increasing the number of varieties of matter or by producing them more cheaply, or by making better use of their properties; if it enables us to make better use of the available energies, if it increases the space that can be inhabited and made use of by men; if it increases the physical or mental power and efficiency of each individual. Truly, the influence of electrical engineering in all these diverse directions has been, and still is, immense, and a treatise could be written on each. Dr. Railing contents himself with a few well-chosen examples. First, we see how ideally natural energy can be harnessed, as is the case with water and wind power—to give electric energy at an efficiency of 90 per cent on a commercial scale. Then there is the question of efficient transmission of generated energy, which can be effected so well that power lines of 50 to 100 miles in length, with 85 to 90 per cent efficiency, are in ordinary use, and this could be pushed still higher if free energy became so scarce that a higher capital outlay for the transmission line were advisable. The only alternative, transmission by radiation, while practicable and carried out for small amounts of energy, is yet impracticable for large quantities, for the same reason that light cannot be transformed conveniently into electrical energy, i. e., because an efficient mechanism of transformation has not yet been discovered. Here is opened up an excellent potential field for research.

Having shown how mankind can benefit from the ready generation and transmission of electricity, Dr. Railing next discusses some of its applications and their merits. Here we are on familiar ground discussing what electric lighting has done for the world, how "it makes us work more efficiently, obviates to a certain extent the differences between the seasons in countries of high latitudes, and prolongs in general the time of work and life under suitable sanitary conditions;" also the advantages of electric heating, "of which we are only at the beginning."

Besides these things electricity has given us a new metal in aluminum; it has allowed us to produce high-class steel in a new way; to produce new substances of great value to the world, e. g., carborundum and calcium carbide, besides having revolutionized the science of extracting metals from the ores. Electrical locomotion is another means whereby human progress has been advanced. It has increased the space which can be inhabited and made use of by mankind. Given a definite number of human beings, an increased rapidity of locomotion has the effect of decreasing distances, thereby increasing the radius of action for every human being. But electricity does more. Since it allows us conveniently to transform available energy, it is a great equalizer. It allows us to produce lower temperatures in hot climates and to produce heat in cold areas; it enables us to irrigate dry territories and thereby bring them under cultivation, it allows us to build canals and recover swamps. Activity of this kind is going on all over the world—in India and on the Panama Canal. It results everywhere in better living conditions, and increases the area that can be inhabited by man.

Finally, Dr. Railing reminds us of the applications of electrical engineering in the direction of the diagnosis and cure of certain diseases. There is the galvano-caustic apparatus for the local application of heat; the Röntgen apparatus and its ally radium, which with their bombardment of corpuscles allow us to see and reach internal tissues without using the knife.

Electrical engineering in thus mastering matter is trying to probe into the mechanism of living organism and problems which concern man's body and mind. These endeavors, in every result that they have achieved, and in every one that they will unravel, mean increase in the efficiency of the individual—the supreme mission of electrical engineering.—*The London Daily Telegraph.*

A Curious Property of Silenium

An interesting experiment with selenium was recently described to the Physical Society, in London, by Mr. A. A. Campbell Swinton. If selenium be mounted on a copper plate and placed in a glass cell containing an electrolyte—tap water by preference—with carbon or copper as the second electrode, the selenium proves electro-positive in the dark, but becomes electro-negative to carbon or copper immediately it is illuminated. Illumination is effected by an electric projecting lantern, a hole being pierced through the carbon or copper plate to allow the light to fall on the selenium.

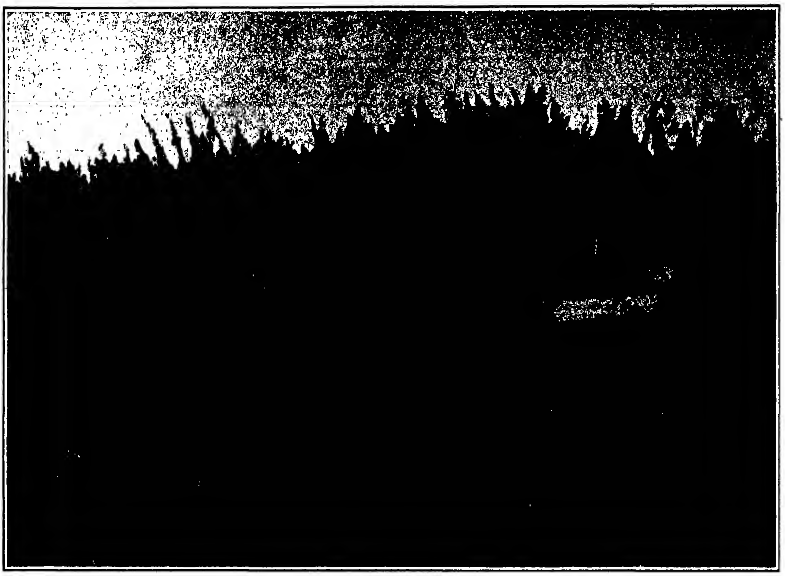


Fig. 1.—Harvesting hemp on an Indiana farm.

Growing Hemp in America

Facts Relating to Its Culture, Qualities and Preparation

By Charles Richards Dodge

If there was ever a time when hemp culture in the United States ought to pay it is the present, as owing to the war in Europe the foreign supply has been considerably curtailed, and prices of all grades have been greatly increased. Our imports of this fiber are derived chiefly from Russia and Italy, the Italian hemp being a high grade, almost white, fiber of superior strength—in fact, the finest hemp produced in the world—and of which this country has taken as high as 4,000 tons in a year. The fiber imported from Russia is of lower grade, darker in color, not so carefully prepared, and of less tensile strength than the Italian, but well adapted to certain lines of American manufacture. The hemp grown in this country is, for the most part, quite inferior to that imported, being a very dark slaty gray in color, and more roughly prepared, but at the same time very strong and adapted to the manufacture of coarse twines and small cordage, for which it is largely employed.

In recent years the American culture has greatly declined, although between 50 and 60 years ago we produced in a year as high as 75,000 tons. But that was before the era of Manila hemp and jute, when common hemp was used for the manufacture of bagging—for baling the cotton crop—burlap, marine and other cordage, even clothing, and other lines. The importation of Manila hemp in increasing quantities started the decline, but the admission of jute butts, free of duty, in 1872, finished the business and drove every hemp mill out of existence. The production of hemp fell to 12,000 tons a year, and in recent years the production has fallen to 5,000 tons or less. Last season's crop is said to have been under 1,000 tons.

While our hemp imports are limited to the fiber of only two or three countries, the plant is almost universally grown. A native of central and western Asia, it has been carried by cultivation into all temperate and tropical climates. It is cultivated in central and southern Russia, Hungary, Germany, France and Italy, and in many portions of Asia—India especially, where it thrives at an elevation of 4,000 to 10,000 feet—and in China and Japan. It is found on both the east and west coasts of Africa, and it has been introduced into Victoria. It is as widely cultivated in the Western Hemisphere, and has been naturalized in South America north of Rio Janeiro. In the United States the culture has been carried on chiefly in Kentucky, Indiana, Illinois, Missouri, Minnesota and California, though the main supply has been produced in the first named State, where the plant has been cultivated for a century. Last year's crop is said to have been the smallest on record, owing, it is claimed, to tariff changes, and in Kentucky to the fact that there is more money in tobacco raising—the low prices that have ruled making the culture unprofitable.

Prices have ranged from 3¼ cents to 6 cents per pound, Russian hemp bringing 7 and 8 cents, with a supply equal to any demand. Now that the American supply is next to nothing, the foreign supply curtailed, and prices soaring—a fair grade of imported fiber bringing 12 cents per pound—it would seem worth while for American growers, especially in Kentucky where the culture is so well understood, to put in an extra crop this year, and pocket the proceeds.

If the European war should continue for several years, as Lord Kitchener predicts, the foreign supply—of Russian fiber at least—may be still further curtailed, and Italy has already put a limit to the amount of hemp that can be exported. However, Italian hemp is too costly for most uses by American manufacturers. In any event there is sure to be a demand for American-grown hemp at fair prices. But to secure "war prices" the quality of the fiber must be improved so as to more nearly resemble the grades of imported hemp with which it would compete.

American hemp is generally dew-retted, that is, the stalks, after harvesting, are spread evenly over the ground in order that the gums which hold the filaments of fiber together may be softened and dissolved by the action of the elements and by freezing and thawing in the early winter storms. This method of retting is practised to a very small extent in Europe where the usual custom is to ret in pits or pools of water, which insures a more even quality of fiber, and a lighter color. American water-retted hemp has been sold at 8 cents per pound when dew-retted was bringing half that figure. When American hemp was used in the United States navy, before the days of Manila and steel cable rigging, the fiber was required to be water-retted.

Hemp is a plant of easy growth, as it flourishes in a wild state in many parts of the world, and in portions of our own country, where it has escaped from cultivation. But simple growth, and growth for good fiber are two very different things, and a farmer going into the culture without knowledge, and a certain degree of skill, will be likely to have only his labor for his pains. Skill is particularly required in the after preparation, when the crop has been grown—that is to say, in the retting and cleaning of the fiber.

To insure the best results in the culture the work should begin the previous fall, when the land is plowed, to be followed by spring plowing and harrowing, for the the ground should be finely prepared. Limestone soils are particularly favorable; clayey loams, or alluvial soils such as are found in the river bottoms are best adapted to this plant, the larger part of the Breton hemp of France being produced along the smaller streams. Light, or dry soils, or heavy tenacious soils are most unfavorable. Kentucky growers, and some in other States, use no fertilizers, claiming that it is not necessary, as the plants do not exhaust the soil, a leading grower in giving his experience stating that he had produced crops for 15 years, successively, on the same land. While this may be true regarding many localities, doubtless the fiber produced could not have competed with even low-grade imported hemp. When New York was a hemp growing State, hardly two decades ago, the growers considered the use of fertilizers of first importance. The foreign

Fig. 3.—Breaking hemp by machinery. A hemp gin in operation.

practice has always been to use fertilizers liberally.

In France a rotation of crops is practised, hemp alternating with grain crops; although competent authorities state that it may be grown continually on the same land, but not without fertilizers. In Italy where the highest grades of fiber are produced, and rich, strong loams are chosen for the culture, the land is highly fertilized. Here is the pratice that was formerly followed in Bologna: First, manure and olive husks; second manures (sometimes hen manure); third, manure and the chrysalides of silk worms; fourth, manure and more olive husks—a "mixed diet," but very efficacious. The tough hemps of Japan and China are largely due to the heavy fertilizing given the soil with barnyard manures. The general practice in Kentucky is to burn the refuse, after cleaning the fiber, and spread the ashes over the land. In a few words, the highest results can only be attained by following in a measure the practice requisite for producing a crop of fine flax fiber, the chief essentials being a thoroughly well prepared seed-bed, and proper fertility of the soil. Weeds are the bane of the flax-grower; but the hemp-grower need not fear them as the hemp plant is a most thorough weed exterminator, and a crop of hemp is sometimes put in to clean a piece of land that has become over foul with the seeds of troublesome weeds.

Of equal importance with soil selection is seed selection, and a well filled seed should be chosen, of a light gray color, glossy and heavy. Mr. Dewey, of the Department of Agriculture, informs me that in a recent letter from Messrs. Glass and Glass of Camp Nelson, Kentucky, it is stated that they have some seed of the Minnesota No. 8 variety, which has been developed by selection at the Minnesota Experiment Station and the Department of Agriculture. Some of the plants of this variety in the seed-breeding plot of the Department, the past season, averaged 3.05 meters high. Regarding the proper quantity of seed to sow practice differs. In France $1\frac{1}{2}$ bushels per acre is considered the proper amount; in Italy $2\frac{1}{2}$ bushels; in New York as high as 3 bushels were sometimes put in, while in Illinois 1 to $2\frac{1}{2}$ bushels are used. The general rule followed in Kentucky for many years has been to use 33 pounds per acre, sown broadcast and dragged in. The method of broadcast seeding employed generally in that State is to use the ordinary grain drill, after removing the rubber tubes, and attaching a board just under the hopper, to catch and scatter the seed as it falls, the drill hoes just behind doing the covering.

After the seed is in the ground there is nothing further to be done until the plants are grown, and the stalks have reached their maturity, which is determined by the finding of ripe seed in the heads—in Kentucky the average time is about 100 days. Harvesting was done formerly with a heavy, hooked implement something like a sickle, but more recently the work of cutting has been accomplished by machinery. The use of sweep-rake reapers has become common, although in some localities an ordinary mowing machine is employed, with a horizontal bar attachment placed about 4 feet above the cutting bar, to bend the stalks over in the direction that the machine is moving. It is said that with a $5\frac{1}{2}$-foot mowing machine, thus equipped, one man and a team of two horses will harvest 6 to 8 acres a day. After cutting, the stalks may be allowed to remain on the ground as left by the machine, although if the crop is heavy they should be turned, as required, to assure uniformity in the curing. A better practice, but one which entails more labor, is to let the stalks lie until the leaves have fallen off, when they are made into small stacks and allowed to remain in stack for a period of two months, after which they may be spread over the ground to be retted. The advantage is that winter-retted hemp is brighter than that done in October.

In these days of highly improved and efficient labor saving machinery, it is somewhat remarkable that the greater portion of the hemp fiber prepared in this country is cleaned on the clumsy wooden slat brake that has been used in Kentucky probably for a century (see Fig. 2). I found a similar form of brake in use in Brittany, though of lighter construction, being made of both metal and wood, and having seven instead of five slats. Breaking hemp in Kentucky, by hand, is an expensive operation, the work usually done by negroes, costing \$1 to \$1.25 per hundred pounds of fiber, and the best workers can clean no more than 150 pounds per day. Only half this quantity is done on a Sarthe farm in France, but the fiber is very much better prepared, and is worth twice as much money. A very primitive machine has been used in Italy, which first crushes the stalks, then cleans the fiber by beating; before the hemp is ready for market, however, it is still further cleaned, and all extraneous matters removed.

It is claimed that nearly 300 patents have been issued in the United States for machines for breaking hemp, the majority of which have proved absolute failures, while only a few have been found practical, most of these turning out inferior fiber. One of the most successful machine brakes, known as the Shely hemp gin (Fig. 3) has been in limited use in Kentucky and elsewhere during the past eight years. The device, mounted on wheels, weighs 7 tons, and is drawn by a farm traction engine which supplies the power when working. With a crew of fifteen men it will turn out 1,000 pounds per hour of clean, straight fiber, ready for baling, the broken

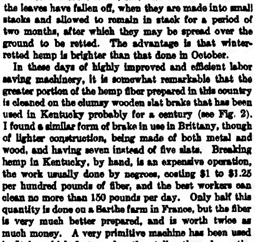


Fig. 2.—Breaking hemp by hand.

fiber and tow being thrown out with the shive and waste matters. In this machine the stalks are fed sidewise and the delivery of the fiber is made in exactly the same manner.

Regarding the cost of hemp production 20 years ago in Kentucky, the expense was estimated at \$24 per acre with an average yield of 1,000 pounds of fiber. A crop of Japan hemp, grown in Kern county, California, cost, including baling and freight to market, \$67 per acre with a return of 7,000 pounds of fiber. In an article on "Hemp" in the year book of the Department of Agriculture for 1913, Mr. Dewey gives the total cost per acre at \$35 (on the basis of a 50-acre plot) with a return of 750 pounds of long fiber and 210 pounds of tow—yielding a profit of \$20 per acre. The long fiber is figured at 6 cents and the tow at 4 cents per pound. In considering these figures it must be remembered that every cent added to the selling price of the fiber is just so much clear profit. That is to say, the expense account being already settled, an advance of 4 cents per pound—or 10-cent hemp—on the basis of 1,000 pounds of fiber per acre, would mean \$40 additional profit. Surely, at the present high prices of hemp, the American culture ought to pay, without regard to tariff considerations.

The illustrations in this article are from negatives by Mr Dewey, Fiber Botanist at the Department of Agriculture.

Gunshot Wounds in War

Delivering a Hunterian oration before a meeting of the Royal College of Surgeons, recently, Sir Watson Cheyne described several interesting experiments which he had carried out regarding the disinfecting of gunshot wounds prior to their being more elaborately dealt with at a base hospital. By means of microscopic lantern slides the lecturer demonstrated the effects of various antiseptics on colonies of bacilli which had been placed on waxy substances, representing suppurating sores. With the exception of one case, where a composition of corrosive sublimate had entirely dispelled the bacilli—much to the surprise of the lecturer—carbolic acid and creosol had proved the most effective. The experiments, he said, had been carried out by a committee formed of Fleet Surgeon Basset Smith, Mr. Arthur Edmunds (attached to the Royal Naval College at Chatham), and himself, and they proposed to pursue these further in the endeavor to solve the problem of effectively dealing with gunshot wounds, which had mystified medical men for ages past.

The object in view was to introduce into such wounds at the earliest possible opportunity after infliction an antiseptic which would remain there, diffuse in the blood of the tissues, and inhibit the growth of the bacteria until such time as the wound could be thoroughly disinfected. He felt sure from the experiments carried out that the dangers attending the necessary delay in conveying wounded from the firing line to the base could be entirely removed, and was hopeful that complete disinfection of wounds could be effected. Such problems, however, could only be solved at the front.—*The London Daily Telegraph.*

Atoms and Ions—III*

A Comprehensive Discussion Especially as Related to Gases

By Sir J. J. Thomson, O. M., F. R. S.

Continued from Scientific American Supplement No. 2053, Page 291, May 8, 1915

In opening his third discourse, the lecturer said that he proposed that afternoon to discuss the subject of ionisation as a result of chemical reactions. Had he been lecturing on this topic ten years ago he could have spoken with much less uncertainty as to the reality of this phenomenon than it was possible to do to-day. For many years, indeed for most of the past century, physicists held, with the utmost confidence, the opinion that chemical action formed one of the most efficient ways of producing electrification. The methodical studies of recent years had, however, shown that the experiments relied on for proof of this proposition were really vitiated by spurious effects. Uncertainty, in fact, arose from two distinct causes. In the first place, electricity was produced when a gas bubbled through certain liquids, and this fact put out of court all the experiments in which gas was generated as the result of a wet reaction. Another disturbing factor was that at high temperatures solid bodies gave out electricity. Many chemical actions were accompanied by a great rise of temperature. Hence, if solid particles were present as a result of the reaction, these would necessarily be at a very high temperature, and would give out the electricity which was formerly attributed to the chemical action.

To illustrate the effect of the source of uncertainty first alluded to, Sir Joseph Thomson placed on the top plate of an electroscope a lead dish containing zinc. On adding hydrochloric acid the electroscope was rapidly discharged, owing to the electrification of the hydrogen generated.

For a long time, Prof. Thomson continued, it was not doubted that in this experiment the electrification was directly due to the liberation of the hydrogen from the acid by the zinc. If this were so, however, in whatever way the acid acted on the zinc, the hydrogen produced should be electrified. In some very beautiful experiments Bloch had, however, shown that when the reaction took place between gaseous hydrochloric acid and finely divided zinc, there was no electrification whatever. The reaction was the same as before, the only difference being that it was not accompanied by the bubbling through liquid of the gas liberated. This experiment proved that former interpretations of the original experiment had been erroneous.

As matters stood there were undoubtedly many chemical reactions which were not accompanied by any perceptible electrification. A very interesting case was that of the combination under diffuse light of hydrogen with chlorine to form HCl. This reaction was one of the most vigorous known, and he had himself employed the most delicate means to detect whether any electricity was liberated by it, but the results were absolutely neutral, even when the rapidity of the reaction were pushed as far as was consistent with the safety of the apparatus. Another very vigorous reaction was, he continued, the oxidation of nitric oxide when allowed to escape into the air.

By adding nitric acid to copper the lecturer liberated nitric oxide, which was passed through a filter of cotton wool to take out any ions due to the bubbling of the gas through the liquid as it was generated. The gas thus cleaned was then directed on to the top plate of an electroscope, and the copious red fumes produced bore evidence to the vigor of the reaction in progress. The electroscope showed no signs of leakage, in spite of the large amount of chemical action in progress.

The cases so far treated were, Sir Joseph proceeded, instances of chemical combination, but processes of dissociation were equally characterized by an absence of electrification. One very interesting instance was the decomposition of nickel carbonyl, which was effected by heat at a temperature below that of boiling water. The nickel was deposited as a bright mirror, and carbon monoxide liberated. This reaction, he said, had been very carefully investigated in the speaker's laboratory by Prof Smith, but not the slightest sign of any accompanying electrification was to be detected. The dissociation of arseniuretted hydrogen, which also decomposed at a comparatively low temperature, had been studied by Bloch with equally negative results. In fact, while it was easy to give instances of chemical reactions which showed no ionization, he would be hard put to it to give a genuine case in which chemical action was accompanied by ionization.

* Reproduced from *Engineering*

The matter might, moreover, be regarded from the viewpoint of the energy changes involved. In the last lecture he had given a list of the energies required to ionise atoms of different elements; that was to say, the amount of work necessary to detach a negative particle from one of these atoms, so as to leave it electrified. Of all those given in his list mercury was by far the easiest to ionise, requiring 4.9 volts, while oxygen required 9 volts, and hydrogen 11 volts. Hence, to electrify an atom of hydrogen or of oxygen would require an expenditure of work represented by at least 9 volts. If this energy had to come from that liberated by chemical action, one would expect that the energy liberated on the combination of hydrogen and oxygen to form water should be greater than 9 volts. As a matter of fact, however, it amounted to a little less than 2 volts. Hence it would appear *à priori* that there was not enough energy available from the chemical combination to effect electrification of either the oxygen or the hydrogen atom. Indeed, the smallest of the numbers given in his list of the previous week represented an energy greater than that developed in any known chemical reaction. Possibly, if the list were extended to include such electro-positive elements as sodium and potassium, this might no longer be true.

Nevertheless the apparent insufficiency of the energy available did not entirely dispose of the question as to the possibility of ionization by chemical action. This would be the case if it were permissible to imagine that chemical action consisted in one molecule of a gas rushing past that of another and seizing on it; but, as a matter of fact, the marriage of the atoms did not take place in this haphazard way. It was not merely the result of chance collisions between particles rushing through space at velocities comparable with those of our largest projectiles. Such marriages always occurred in regions more densely populated than the average viz., where the gas was condensed on the walls or on nuclei floating in the gas. This being so, it might quite conceivably take less energy to electrify the atom or molecule in a solid or liquid condition than in the gaseous state.

In his first lecture he had shown, the lecturer said, that when ultra-violet light fell on a clean zinc plate, negative electricity was liberated and escaped, leaving the zinc positively electrified. Now there was reason to believe that a definite amount of energy was associated with each kind of light, this amount being inversely proportional to the wave-length. Thus, in the case of the mercury line having a wave-length of 2,536 Angstrom units, the energy associated with this wave-length corresponded to 5 volts, which was that required to ionise the mercury atom, and light of this wave-length could accordingly ionise mercury vapor. This light lay in the ultra-violet; and in the visible spectrum, the wave-length being longer the associated energy was correspondingly less, and if one went up to the extreme limits of the red—viz., to wave-lengths of about 7,000 and 7,500 Angstrom units—the energy available for ionisation would be only about one third of 5 volts, or, say, 1.6 volts, which was not greater than was liberated in certain chemical reactions. This red light, though of too long a wave-length to be visible, was, nevertheless, competent to cause a liberation of energy from certain kinds of solids.

To show this, the lecturer employed a glass vessel coated inside with a very thin layer of rubidium. The interior of the vessel was connected by one electrode to an electroscope, and by the other to earth. The light which passed through the ruby glass of a photographic lamp was allowed to act on this rubidium cell, all other light being excluded, and under these conditions the electroscope showed a very rapid leakage of electricity. This occurred, although the wave-length of the light reaching the rubidium was very long, and had associated with it a correspondingly small amount of energy. These rubidium cells were, the lecturer said, quite as sensitive to light as the eye; in fact, some workers claimed them to be even more sensitive. The glowing carbon of an extinguished match would, he said, excite the cell so long as any visible redness remained.

From this experiment it appeared that if we were dealing with solids, the energy available in chemical reactions might be sufficient to provide for that required in ionization, and the rubidium cell was, in fact, relied on as a proof of their case by those who regarded as established the reality of ionization by chemical means.

A great number of experiments had, in fact, been made by Haber and Just with this cell, and also with another in which the rubidium was replaced by the curious liquid alloy formed by potassium and sodium. This alloy, the speaker continued, closely resembled mercury in appearance, and he recalled incidentally its use by an American inventor in an attempted fraud on Prof. Rowland. The latter had been commissioned to investigate certain claims made by this inventor, and reported that if these were justified, it should be possible to make a barometer in which the mercury would stand far above the normal 30 inches. The inventor accepted the challenge, and brought forward one in which the liquid (to all appearance mercury) stood at a height of some yards. Investigation showed that the mercury had, in fact, been replaced by the sodium potassium alloy.

This alloy, Prof. Thomson continued, liberated electricity under the action of light just as rubidium did. Haber and Just used rubidium inclosed in a highly exhausted vessel which they kept in the dark, and into it they passed small amounts of bromine or of phosgene gas. On the entrance of this gas electricity was liberated, and on determining in the usual way the nature of the carriers, those proved to be negative particles. The experiment was repeated several times, and in all cases it was found that the liberation of the electricity took place when one of tha above-mentioned gases was admitted. They attributed this ionization to the chemical action. It was conceivable that they were correct, but many difficulties would have to be overcome to be sure of a clear-cut issue, even in what was apparently so very simple an experiment.

The speaker had himself, in experiments made some years ago, used rubidium inclosed in a vessel exhausted to the highest degree by means of charcoal and liquid air. Though the cell was kept in the dark, some electricity was always liberated, even under the very highest vacua, although neither bromina nor phosgene gas was present. The apparatus was kept in the dark, and in a specially darkened room, the efficiency of the precautions taken being tested by exposing a very sensitiva plate alongside the apparatus for four days. This plate, when developed, was quite clear from any signs of fog. Nevertheless, electricity was liberated, even at the highest vacua. He found, however, that its amount was very much increased by the admission of small quantities of hydrogen, which intensified the rate of leakage several fold. It was therefore not at all clear that in Haber and Just's experiments the effect of the gas admitted was due to its chemical action on the rubidium.

He would just allude to some results which showed the immense influence which might be exerted by films of gas formed on the surface of metals. A very conspicuous example was that of the emission of electricity from hot bodies. A platinum wire raised to a moderate red heat gave out a large amount of positive electricity. If the same wire were, however, cleaned with nitric acid and hydrogen eliminated with every possible precaution, the electricity liberated, at the same temperature as before, fell to less than one millionth of its former value. The presence of a film of hydrogen on the platinum had, therefore, an enormous effect. Another case was afforded by the action of light on rubidium itself, or rather on other metals which would not oxidise. The action light on such metals was recognised as being very fickle, and this variability was due to layers of gas condensed on the surface of the metal. If this layer were increased or removed, the effect was extraordinarily large.

The action of such films might be explained by imagining that this gaseous layer was electrified. If the electrification were positive, it would help the light to pull out negative particles from the metal. The effect would, therefore, be due to something which was not what was ordinarily implied by the term "chemical action." Hence it was not possible as yet to say whether photo-electric effects due to light of very long wave-length was not responsible for the results observed by Haber and Just. Light of this character was found even inside a closed box, and the electrical effects found might be due to a layer of gas condensed on the surface of the metal. Certainly some experiments showed that no electrification was obtained if the layer of gas were [illegible]. Many experiments, for example, had been made with potassium, with which similar [illegible] with rubidium were obtained. [illegible]

windows half a dozen times from vessel to vessel, so as to free it from gas condensed on its surface, it was found that no photo-electric effect was to be observed, although ordinarily the metal responded readily even to feeble light of quite long wave-length. This was strong testimony to the great influence of surface layers, and made it all the more difficult to be sure that the effects observed by Haber and Just were not really attributable to a surface film and not to chemical action.

Methods of measurement were now so perfect that almost infinitely small amounts of electrical dissociation of a gas could be detected. Thus in a gas strongly electrified by means of Röntgen rays, not one molecule in a million was electrified. The speaker had worked out from a formula of Boltzmann the number of particles which would be electrified in a gas at different temperature in virtue of the molecular collisions. Denoting by N_0 the number of molecules not electrified, by N_1 those negatively electrified, and by N_2 those positively electrified, the formula arrived at was:

$$\frac{N_0 V}{N_1 N_2} = \frac{\pi a^3 \Sigma \overline{R\theta}^{\frac{w}{}}}{\frac{w}{R\theta}}$$

where V denoted the specified volume of the gas, $R\theta$ the energy possessed by a molecule (about one thirtieth volt at 0 deg.), a the radius of the atom or molecule, and w the energy required to ionise a particle.

This equation, he should add, represented an ideal to which the phenomena in question might attain, but which need not necessarily be reached within a finite time. All such expressions were obtained by finding an arrangement which gave the minimum value of some function. Thus in the simple case of the equilibrium of bodies under gravity, the general theorem was that the State was most stable when the center of gravity of the whole masses involved was at the lowest possible level.

If this were accepted without qualification, we should expect to find the whole population of the globe concentrated in its nethermost pits. Such formulæ, however, made no allowance for difficulties to be overcome in getting there. Water in a glass on the table was, from the viewpoint of the general theory, less stable than if spilt on the floor; but before it could escape to the latter it would have to have work done on it to raise it above the edge of the glass. Again, calculations based on these very general principles led to the conclusion that if hydrogen and oxygen were mixed together at ordinary temperatures, a by no means insignificant proportion of water would be formed. There was, however, reason to believe that the two gases might be left together for centuries without sensible combination occurring. In fact, for the reaction to proceed, an uphill road had to be traced at the outset, and a catalytic agent was needed to surmount the rise. Such an agent acted as a siphon would in emptying a lake into the sea. It absorbed no energy, but helped the system uphill.

Premising this, the formula given showed that at 2,000 deg. Cent. about one particle in 74,000 of a gas should be ionised. This was quite a large number as compared with the ionisation effected at ordinary temperatures by Röntgen rays. Hence electrification by high temperatures was quite within the bounds of possibility. On the other hand, at 0 deg. Cent. the formula gave the result that in 10^{60} particles of the gas only would be electrified. Since there were only 10^{19} molecules in a cubic centimeter of gas at normal temperature and pressure, it would be necessary to take a liter of gas to include a single charged particle.

The formula was therefore consistent with the known properties of gases at ordinary room temperatures and with the conductivity of flames. If to a flame, sodium was added, a metal which required less than the 10 volts or so needed to ionize oxygen or hydrogen, the number of electrified particles was largely increased.

The effect of heat on the liberation of electricity was of very great importance also in other respects. It might, for instance, alter the nature of the carriers of the electricity. These were generally molecular aggregates consisting of a few molecules each. In some chemical actions, however, large nuclei were produced, and to this nuclear dust the particles adhered, so that the light and easily movable carrier was replaced by a great, heavy one, hard to drag along.

Dried Beer-Yeast as an Article of Food

The necessity of husbanding the food supplies of Germany during the present war has led to a search for new sources of nutriment, from which additions to the daily fare of the nation might be obtained, and in this scrutiny the skill of the Germans in chemistry stands them in good stead. Attention has been called to the nourishment contained in straw, which would be of service if it could be extracted. Another proposition is to make use of dried beer-yeast as an ingredient to improve the flavor and dietetic results of various dishes. The surplus yeast contained in the scum and dregs of beer has not so far been put to any great use in Germany, excepting as feed for animals and as a fertilizer. There is, therefore, a large amount of raw material to work on if the suggestion, carefully elaborated in the German journal, *Umschau*, by Prof. E. Weinwurm, should be carried beyond the trial stage.

Van Leeuwenhoek, a Dutchman and the son of a brewer, was, in 1680, the first person to investigate microscopically the yeast of fermented wort, which he described as composed of small globules. It was not until the first half of the last century that it was recognized by investigators, as Latour, Schwann, and Kützing, to be a vegetable growth, developed from a single cell and propagated by germination. Meyen gave it the name of sugar fungus or *Saccharomyces*, owing to its property of fermenting a solution of sugar. The practical working of the ferment was known long before this, even though its nature was not understood. All brewed liquors in these earlier days were produced apparently, from remotest time, by self-fermentation. In reality, the yeast fungi floating in the air and the same on the surface of the malt and hops penetrated the liquid and caused the fermentation. The froth rising to the surface and consisting largely of new-generated yeast was regarded formerly as an impurity thrown out by the fermenting liquid that should be removed. In the seventeenth century the discovery was made in England that this froth could produce rapid fermentation in a wort. Consequently after this in brewing beer the yeast gained from one fermentation was used to cause another. Pasteur showed that beer-yeast was often filled with bacteria. His researches were followed by those of Hansen who discovered a process of producing pure yeast. In Hansen's process a microscopically determined culture yeast cell is propagated, under exclusion of all infection from other organisms, until a sufficient amount of pure yeast is gained to ferment a specified quantity of wort.

So much yeast is obtained during fermentation that the greater quantity of it cannot be used in the producing brewery. This surplus in Germany amounts annually to about 70 million kilogrammes and in Austria-Hungary to over 37 million kilogrammes. Some 10 million kilos of this extra quantity is taken annually for making bread-yeast. Fresh yeast from beer contains 75 per cent of water and a large amount of albumen, so that it spoils easily. This is a drawback to its sale as animal-feed, and although its large content of nitrogen and phosphoric acid make it an excellent fertilizer, the price paid for it is not in proportion to its value. Neither is the medicinal use of dried yeast sufficiently large to reduce materially the waste. Consequently, according to the writer in the *Umschau*, the only rational way of employing the surplus beer-yeast is to use it dried both as feed and food. In 1910 the research institute at Berlin for trades using fermentation took up the question and found by practical experiments on horses, sheep, hogs, and poultry, that the dried yeast was an excellent feed, when it was freed from living cells and enzymes and had the water squeezed out. It was easily digested, nourishing, and readily eaten by the animals. As a result of such investigations the yeast from beer is now dried for food in twenty-three drying factories in Germany and five in Austria.

It was only natural after yeast had proved to be so wholesome for animals that research should be made to make it serviceable as human food, especially as it was already used for raising bread. The writer of the article gives a comparison in percentages of the chemical composition of the beer-yeast dried for food and medium fat beef. He shows that the beer-yeast prepared for food contains 54 per cent of albumen, 7 per cent of ash, 3 per cent of fat, 28 per cent of extractive substances free from nitrogen, and 8 per cent of water, while beef contains 21 per cent of albumen, 1.5 per cent of ash, 5.5 per cent of fat, no extractive matter free from nitrogen, and 72 per cent of water.

"According the statement of Prof. Cluss," continues the author, "the yeast dried for food has the following average composition: 6/8 per cent of water, 53/58 per cent of raw protein, 3 per cent of fat, 25/30 per cent of extractive matter free from nitrogen, included in which is up to 20 per cent of glycogen, and 7/9 per cent of ash. These figures show what an exceedingly valuable article of food the yeast is, and consequently how suitable to take the place of meat, and this all the more as the raw protein in its composition resembles not the albumen of vegetable food but that of meat. Along with its high content of albumen the yeast prepared for food is also marked by great digestibility, whereby the eater digests 90 per cent of it and 86 per cent of its albumen. The ratio of nutriment between yeast prepared for food and beef is as follows: 1 kilo of medium fat beef contains 1,370 calories, 1 kilo of yeast prepared for food contains 4,520 calories. Consequently 1 kilo of prepared yeast corresponds to 3.3 kilos of beef. In this yeast the purchaser obtains for 1 Mark (25 cents) 904 calories, from ordinary beef 623 calories, from fine beef 278 calories. The yeast prepared for food is therefore cheaper than ordinary beef."

The albumen of yeast contains 26 per cent of nuclein and the dried yeast about 2 per cent of lecithin, substances which hold a large amount of phosphoric acid, so that the ash is rich in phosphoric acid. The yeast prepared for food contains about 7 per cent of ash, 55 per cent of which is made up of phosphoric acid (P_2O_5). This phosphoric acid in the ash consists of 65 per cent of organically combined acid and 35 per cent of inorganic, therefore the yeast prepared for food contains 2.4 per cent of organically combined phosphoric acid. As much emphasis is laid upon organic phosphoric acid in dietetic treatment for recovery of health the yeast dried for food has proved a valuable aid in such cases. According to our author, when taken in small amounts several times a day, it stimulates the appetite (hardly a result to be desired should food fail), and in a short time has an invigorating effect upon the general health. The prepared yeast having been well tested and recognized by the German medical profession, it is now much used in the large hospitals and charitable institutions in Germany and in the feeding of wounded and convalescent soldiers.

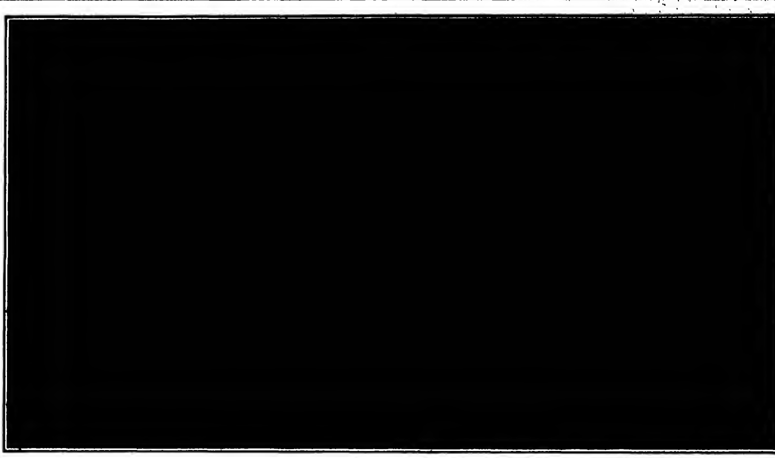
"As regards its preparation," continues Prof. Weinwurm, "the surplus yeast is first sifted and washed, then the bitter principle of hops still existing from the fermentation of the beer is extracted. After this it is dried in a rolling machine at 125 deg. Cent. This heat suffices to destroy the vitality and enzymes of the yeast, the reverse of the process for drying yeast for medicinal purposes, where the vitality and enzymes of the yeast are preserved. The exposure to heat is so short that no essential chemical changes occur in the yeast excepting loss of water and destruction of enzymes. The scale-like yeast is ground to powder and protected against dampness both in storage and transport. The yeast has a yellowish-white color, an agreeable odor and smell."

Our author thinks the era of war the right time to try this food-yeast in the kitchens of the German nation to supplement any scantiness in the supply of meat. To do so would help the larder and prevent the economic waste of the yeast. Practical experiments in using the yeast for food were tried in 1910 at Berlin by the research institute for trades using fermentation in a manner similar to the experiments on the "poison-squad" at Washington. For four weeks 12 men belonging to the institute received daily at noon 20 grammes of the food-yeast prepared in various dishes, which they ate with hearty appetite and good results. They were all in excellent health, gained in weight, and felt fresh and full of energy during the entire experimental period.

Similar experiments were carried on at the research institute at Vienna of the brewing and malt industry, under the supervision of its director Prof. Cluss, who sought to introduce the use of yeast prepared for food in Austria. Several tests were made there with soups; one was a vegetable soup without meat, a second had 8 grammes of the yeast added instead of meat, a third was made with soup-stock instead of water, while a fourth contained both soup-stock and the yeast. The volume of each experiment was 0.25 liter, a little butter was added in every case, and the cooking was carried on for half an hour, the water lost in boiling being replaced by hot water. The result was the following: the first soup was miserable, the second proved a good average soup, while the third was decidedly better, and the best of all was the fourth in which both soup-stock and the yeast had been used.

The author also tried some experiments in his own household and found that from one fourth liter of water, 8 grammes of the food-yeast, and salt, a good-tasting soup could be made, somewhat similar in flavor to bouillon. Of his experiments in cooking vegetables he says: "Carrots prepared as a vegetable with water, salt, and the usual ingredients only, and without the food-yeast, were quite tasteless. When, though, the yeast was added, as 2½ grammes per person, the dish had a substantial, agreeable flavor. As it is customary in the house-keeping of the well-to-do to prepare vegetables with the aid of soup-stock, a similar parallel experiment was tried with and without the food-yeast in the stated quantity. Vegetables prepared with soup-stock and food-yeast had much the best flavor, being thoroughly enjoyable. No taste of the yeast was perceptible in the dishes. As the result of my own experiments I can, therefore, say: Food-yeast not only increases the nutritive value of viands but also lends them an excellent substantial flavor."

The yeast has also been used in the preparation of other kinds of food, as zwieback, cake, chocolate, cocoa, and even cheese.



This hull consists of nine circular welded sections. Upon this is built the lighter outside hull of surface torpedo-boat form.

The inner cylindrical section of the latest submarines for the Austrian navy.

The Submarine in Naval Warfare—II*

Problems of Design, Construction, and Recent Tactical Developments

By R. H. M. Robinson

Concluded from Scientific American Supplement No. 2053, Page 298, May 8, 1915

All of the submarine operations so far chronicled during the present European war may be said to be in the nature of naval raids, as distinguished from strictly tactical evolutions. The surface radius of even the smaller types of submarines is quite sufficient for any of the raiding operations of which we have read.

Undoubtedly the submarine proceeds on the surface to a point where previous reports indicate that the enemies' ships are, or are apt to be, then comes to the awash conditions and waits. If his quarry is sighted, he may submerge and await him, or so direct his course as to cross that of the enemy.

The fact that he was a long way from his base was, at least in the early days of the war, an undoubted benefit to the submarine, as no one suspected him of being there, but, even if they did, his invisibility when submerged and his close approach to it even on the surface make him reasonably safe, though on a long run the crew might not be luxuriously comfortable.

It is quite possible that the submarine will continue to be most heard from in this form of operation, to which its inherent qualities are well adapted. The moral influence of this hidden danger and its constant wearing away of a near or far blockading fleet or one patrolling the seas to keep them open, as the British fleet is doing in this war, is not to be underestimated in its effect on the fleet itself or the public whom the fleet represents.

I have it on very reliable authority that the Germans in the present war, in some instances, have used a fishing boat or some other surface vessel, pretending it to be a mine-layer, as a decoy.

The question of the tactical use of the submarine in groups is, however, of importance and will become increasingly so. The maximum range for successful attack of a submarine is limited by the circle of visibility. The sea horizon, viewed from a periscope 20 feet above the surface, is just 10,000 yards. At this range the horizontal angle subtended by a 600-foot target is a little under one degree. When the periscope height is 3 feet above water the sea horizon is distant 4,000 yards, and when one foot exposed becomes 2,200 yards.

The practical difficulties of finding and then firing at specks on the horizon are so many as to compel the submarine to take advantage of her invisibility and immunity from gunfire, to push the attack to close quarters—2,000 yards or less—or, if unable to do this, then to hold fire until more favorable opportunity offers.

What I shall give you now as to submarine tactics is quoted in some part from a paper prepared by one of our best submarine officers, and may be said to have the weight of experience behind it.

Before entering into a discussion of the tactics of submarines, one should first consider the various means of communication between submarines and scouts or shore stations before sighting the enemy, and between submarines themselves after sighting the enemy.

On the surface the submarine has the following means of signalling, the order of their estimated value being as given:

Radio (day or night).
Searchlight (day).
Searchlight (night).
Shape signals (day).
Flag signals (day).
Wigwag or semaphore (day).
Very's start (night).
Wigwag torch (night).

Submerged the submarine has the submarine bell signal apparatus, and, more recently, the Fessenden oscillator, which performs the same function even more satisfactorily.

The submarine bell can be used between submarines or between submarines and tenders or shore stations, at distances varying with the attending circumstances. Under the most favorable conditions (i. e., all machinery stopped) signals may be exchanged at distances up to 8 miles with fair success. With machinery running, and under the most favorable conditions (i. e., boats running in opposite directions), signals may be exchanged at distances up to one half mile.

Of the various means of signalling, none can be used in the face of the enemy without danger of betraying the presence of the submarine group.

As the submarines of the types at present in existence have a submerged speed probably inferior to the surface speed of the enemy, and as in that case the enemy can keep out of torpedo range, it is important that no signals be sent that might give the enemy warning of the presence of submarines.

It may be wise to here give definitions to the terms "light condition," "awash condition," and "submerged condition," so that later references may be understood.

A submarine in the "light" condition has all of its water-ballast tanks empty and has its cruising bridge rigged.

A submarine in the "awash" condition has only those water-ballast tanks empty which are habitually kept full when running submerged. The fore-and-aft trimming tanks and two smaller tanks, called the auxiliary tank and adjusting tank, are filled with just enough ballast so that when the main ballast tanks are filled the boat will be immediately ready for running submerged without further adjustment of ballast. The quantity of water in the trimming tanks and in the auxiliary and adjusting tanks, in the "awash" condition, is so small, in comparison with the total ballast, that the submarine has practically the same stability and safety as when running "light." In the "awash" condition a small section of the bridge may be kept up for the lookout, and the conning-tower hatch may be kept open and the radio rigged.

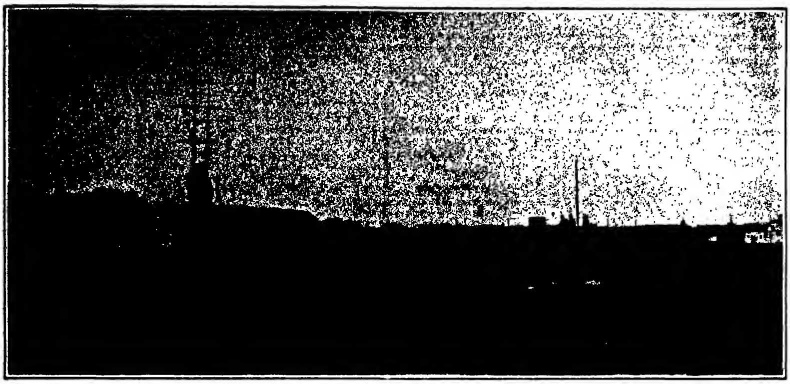
A submarine in the "submerged" condition has the ballast tanks and other tanks so filled that there still remains a small reserve of buoyancy (0 to 800 pounds) and is all ready for submerged running.

For the purpose of tactics, submarines may be divided, according to their capabilities, into three classes, viz.: harbor defence, coast defense, and sea-keeping offensive submarines.

The tactics of a group of harbor defence submarines are simple. Their limited submerged radius and speed do not enable them to operate far from the entrance of the harbor which they are protecting. The lack of reliable under-water communication makes it impossible to change plans of action, once their group is submerged, without giving the enemy a clue as to the submarine's whereabouts. Any form of under-water signalling device in use at the present time can be accurately located in direction by the enemy. The apparatus for locating the direction of submarine signals is installed on practically every modern ship. For this reason alone the detailed plans for a group of harbor defence submarines must be made explicit enough to cover in advance every plan of an attack by a determined enemy.

Each boat of a group would be assigned a certain area outside of the harbor as its zone of defense, these zones to be so selected that all approaches to the harbor

* Journal of the Franklin Institute.



Length, 142 feet; breadth, 12 feet 4 inches; draught, at surface, 9 feet 8 inches. Displacement: Surface, 235 tons; submerged 300 tons. Speed: Surface, 12 knots; submerged, 8.6 knots.

One of two German-built submarines for the Austrian navy.

are protected, and to be at such a distance from the point of defence that the enemy will never come within gun range.

Most of our harbors lend themselves naturally to such a method of defence by the form of the channels leading to them or by the presence of islands in the vicinity. A harbor defence group, having received warning from scouts or shore stations of the movement of the enemy off the coast, immediately proceeds to the entrance, leaving the tenders inside the harbor. Submarines anchor in the "awash" condition, radio up, in the centers of their zones, and keep a lookout for the enemy. By sub-dividing the total area outside of each harbor into small squares and using short code words to designate squares and directions, scouts in touch with the enemy can easily keep the waiting group of submarines informed as to the enemy's movements.

The waiting submarines, having been warned that in all probability the enemy will pass close to their harbor, are prepared and immediately get up their anchors and submerge as soon as smoke appears on the horizon.

With a moderate amount of their periscopes exposed, a submarine can easily see a large ship in clear weather for a distance of 7 or 8 miles. The submerged group, each boat in its zone, remains stationary until the movements of the hostile fleet are definitely ascertained. By the arrangement of the zones the enemy must pass close to one submarine; the other boats would then move over toward the enemy at such speeds and with just periscope exposure to enable them to get within torpedo range without detection. Once within torpedo range, they keep their periscopes exposed and make all speed possible to get within easy torpedo range to fire their torpedoes at that part of the enemy's formation previously assigned to them. In this last maneuver each boat would act regardless of the other boats and must take the risk of collision. On this final charge the submarine bells may be rung continuously to assist the submarines to keep clear of each other. Having fired their torpedoes, the boats submerge totally, and reload their tubes if they have spare torpedoes. During the period of reloading they may run at such depths as would enable them to pass under the enemy's vessel, or, if the depth of the water permits, they can rest on the bottom until the reload is finished, when they should return to the surface to inflict such further attack as is possible. A submarine, having exhausted her supply of torpedoes, has still a most formidable weapon in her ram. This has been proved in several instances where accidental ramming has occurred.

The harbor defence group, having exhausted its means of offence, should return to the tender, submerged, if necessary, under cover of darkness, to replenish torpedoes and storage batteries.

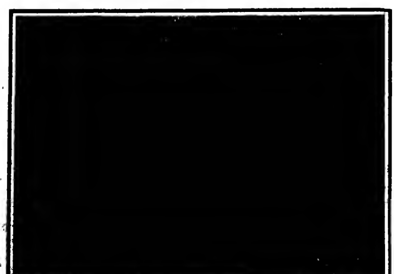
For the night defence of the harbor submarines remain on the surface in their zone, being used in this manner most effectively as surface torpedo boats. The tactics on the surface as torpedo boats are similar to the tactics employed in surface torpedo craft, though as such they are somewhat less efficient, owing to their lesser speed.

The distinction between a coast defence and a harbor defence submarine lies principally in the greater submerged and surface endurance, the greater submerged and surface speed, and the better habitability conditions of the coast defence boat, which gives it a wider range of action than its smaller sister.

It will be noted that in the defence schemes for east and west coasts submarines of the coast defence types were referred to. A coast defence group will accomplish with greater effect the same duties that are now accomplished by the harbor defence group.

In considering the tactics of a group of "coast defence" boats it is assumed that information has been received from reliable sources, scouts or shore stations, that the enemy's fleet is approaching our coast with the evident intention of seizing a base or of landing a force. The group proceeds at its highest reliable surface speed, in column, in the "awash" condition, with radio up, to intercept or to come in contact with the enemy. The submarine, with its low hull, can easily distinguish the masts and other characteristics of a vessel when the submarine cannot be seen at all. On sighting the smoke or masts of the hostile fleet, and having approximately determined its course, the entire group immediately submerges, after rigging down the radio, and proceeds submerged at about one half mile distances, in the general direction of the enemy, at such speeds and under such general instructions as may have been previously issued by the group commander. The boats of a submarine group, submerged at one half mile distances, can easily keep clear of each other.

They should then maneuver to keep a position on either bow of the enemy's column in order to insure their getting within torpedo range before being sighted. By "torpedo range" is meant 2,000 yards. This approach must be totally submerged, with an occasional "porpoise" or periscope exposure of short duration. When within torpedo range periscopes should be exposed enough to keep an easy bearing on the enemy, and the speed increased as much as possible to arrive within easy range (between 500 and 1,000 yards) before the enemy has time for a concerted maneuver. Each submarine fires its torpedoes at the parts of the formation previously agreed upon, totally submerges, reloads as soon as possible, and



The hand-wheel operates the diving rudders used for steering in a vertical plane. In front of the wheel is a gage whose pointer shows the depth of the boat. The curved dark line below pointer is a spirit level which shows the inclination of the boat.

Diving wheel and depth pressure gage.

This shows the roof, not the floor, of the submarine interior. The horizontal eyepiece and the vertical telescope tube are rotated by means of the hand wheel whose pinion engages an internal gear ring.

Eyepiece at bottom of periscope.

returns to the attack. Using 18-inch torpedoes capable of angle fire, a four-tube boat should set one torpedo to run 5 degrees to port of her keel, two to run straight ahead, and one to run 5 degrees to starboard of her keel.

The movements of each individual boat in contact with the enemy will be dependent on the enemy's formation. A table showing the proper bearings on which to fire torpedoes with maximum chances of hits has been compiled for every possible formation, and is readily understood by submarine officers. It is not to be hoped that every shot will be a hit, nor that every ship of the enemy's force will be disabled. It is to be reasonably expected, however, with the above method of firing, enough damage will result from the discharge of twenty torpedoes to prevent the enemy from accomplishing its purpose.

With accurate knowledge of the enemy's whereabouts off the coast, two or more coast defence groups may be dispatched to the probable destination of the enemy to deliver an attack as shown above.

Submarine groups having exhausted every means of offense, including the torpedoes and ram, should withdraw submerged at low speed or lie on the bottom, if that is possible, until nightfall, and then return to the base of supplies under cover of darkness, charging their storage batteries on their way to the base.

All attacks so far have been assumed at an enemy which is moving. Should the attacking group discover the enemy at anchor, landing troops or establishing a base, it should continue as above outlined, totally submerged, with only an occasional "porpoise" of short duration, until well within torpedo range, when the periscope should be kept exposed until the torpedoes are fired at easy range at pre-arranged parts of the enemy's formation. No special difficulty should obtain in passing the line of the enemy's scouts or pickets with the submarines running totally submerged with occasional "porpoises."

After the reload of torpedoes the submarines must act absolutely independently, as it is probably impossible with the present lack of under-water signal facilities, to communicate. In all cases the chief duty and aim of the group commander must be to bring all of his group *into contact with the enemy and within torpedo range at the same time.* Having done this, it is up to the individual commanding officers to produce results.

A "sea-keeping offensive" submarine has been defined above as a submarine which can keep the sea, ready for duty, under all conditions of weather, for considerable periods. Such a submarine group could obtain its supplies from vessels of the fleet which it accompanies, and be as mobile as any unit of the fleet.

The tactics of such a submarine group after contact with the enemy will be the same as the tactics already described for harbor defence and coast defence submarines in contact with the enemy. The problem of maneuvering such a group into contact with the enemy, or, to state the case more accurately, the problem of maneuvering the enemy's fleet into the "submarine danger area," must be solved by the commander-in-chief.

As an illustration of the use of one or more offensive submarine groups accompanying a fleet, let it be assumed that the submarines have a surface speed capable of cruising with the fleet at any speed that may be required to keep up with the fleet. Let it also be assumed that the submerged speed and the radius of the submarines is about 12 knots for 1 hour, or about 8½ knots for 4 hours, or about 5 knots for 15 hours—all within the range of present-day possibilities. Suppose, also, that in the cruising formation submarine groups take position on either flank of the fleet. The submarine groups are in the "awash" condition, ready for instant use. The commander-in-chief, having received information from his scouts of the presence of the enemy, or having sighted the enemy, should immediately send his submarine groups "awash" off on a bearing previously decided upon, and then endeavor to maneuver his opponent into the area occupied by the submarines.

The submarines may remain "awash" until the enemy's smoke or masts are sighted. If our commander-in-chief possesses a superior speed, he can choose his own position, and, having patience, can eventually bring the enemy into the submarine area. In this case submarine groups should maneuver "awash" or "submerged," as is necessary to keep out of the enemy's sight, and endeavor to attack the enemy's formation as soon as possible without interfering with the movements of the commander-in-chief.

If our commander-in-chief has the inferior speed and inferior force, and if the enemy is determined to bring about an action, the problem of making him cross a submarine danger zone is greatly simplified. The appearance of several groups of submarines within or very close to the enemy just before a general gun action would undoubtedly cause the enemy to so alter his plans and formation that he would be at a temporary disadvantage. Even if all the torpedoes shot missed, the effect on the morale of the enemy would be sufficient to give our commander-in-chief a temporary advantage. Most of the important fleet actions have been fought in sight of land or close enough to shoals to cause the movements of the vessels in action to be somewhat restricted as to courses. In cases of this character the commander-in-chief can so station his submarine groups as to increase the chances of forcing the enemy into the submarine danger area.

If the commander-in-chief desires to withhold the submarine attack until after the gunfire, the submarine group should be kept in the background within easy radio signal distance, but in doing this the commander-in-chief will probably find it will be more difficult for the submarine groups to make a successful dash across the space between the engaged fleets, due to the inferior speed of the submarines submerged. Ships of the enemy that are already disabled would in such cases become easy prey for the submarines. Submarine groups accompanying a fleet are decidedly offensive weapons and of the greatest value when used just preceding a general gun action.

A ruse which might assist in forcing the enemy to keep away from certain areas and thus increase the chances of making the enemy cross the submarine danger zone would consist of having the fast scouts of the fleet drop numerous poles, properly weighted, to float upright in the water, and painted to look like a submarine periscope. These same dummy periscopes floating out of a harbor with an ebb tide or dropped outside by scouts or fishermen may greatly influence the movements of an enemy sighting them. It is extremely difficult to distinguish between dummy and real periscopes, for it is easy for a submarine to lie submerged and stationary with only a small amount of periscope showing.

Something of this kind has been successfully done in fleet maneuvers several times.

The night maneuvers of a submarine craft are the same as for surface torpedo craft, and the same tactics apply. As there is no possibility of "torching," and as the hull is so low in the water, it is extremely difficult to pick them up at night, even in the full rays of the searchlight. The maneuvers off Provincetown in the summer of 1911 demonstrated that in nearly every case the submarine could come within easy torpedo range of the enemy at night without detection. In a night attack submarines should remain in the "awash" condition, so that in case of self-preservation, or to pass through a picket line, the submarine can quickly submerge.

It may very well be that while I have been talking to you the submarine has again demonstrated its effectiveness, but whether so or not, it has already done enough to make its power felt.

A weapon to which there is no defence and no reply is one not to be lightly put aside, and no navy wanting in adequate number of submarines is complete.

Commercial Glucose and Its Uses*

A Misunderstood Product, Necessary for Certain Food Staples

By George W. Rolfe

Most well-informed people know that in the early part of the last century Kirchoff was the first to describe a sugar made by boiling starch with dilute sulphuric acid, and that this sweet, subsequently found to be other than cane-sugar was called "glucose" or "grape-sugar." Later it was termed "dextrose" when in the progress of science it became necessary to distinguish the individual from a whole family of "glucoses" which had been discovered.

Nowadays, most of us have heard of "glucose" as a commercial product of doubtful reputation. People look askance when glucose is mentioned. Confectioners and grocers make haste to deny that glucose ever appears in their products. Glucose is classed with harmful food adulterants, and has been called by pure food experts the "champion adulterant" of all. It has even been depicted in cartoons as a devil with hoofs and horns. Glucose has also been called "mucilage," the implication being that it is only fit for postage-stamps and not for human stomachs. This may be why many associate glucose with glue. The names sound alike and both are sticky, but the reasoning is like assuming that all gentlemen are gentiles. Glucose makes a rather poor adhesive, but one who is hard put for mucilage might so use it with indifferent success just as it is possible to use tapioca pudding, molasses or other sticky foods.

Turning to the advertising literature of the glucose manufacturers, we note that many eminent authorities laud glucose as most wholesome, that it is the principal sweet of fruits and one of the intermediate products of the digestion of starch in the human organism, is found in the blood,—and similar statements, all of which like the damping ones of some pure food experts are "important if true."

Notwithstanding that annually between thirty and forty million bushels of Indian corn are made into glucose, comparatively few except those engaged in the numerous industries in which glucose enters, ever see the product. The idea of the general public, professional as well as the laity, seems to be that glucose is mostly composed of grape-sugar which is made according to the Kirchoff method by boiling starch and oil of vitrol and neutralizing the mixture with chalk. Many supposedly up-to-date cyclopaedias make such statements.

Much of the ignorance concerning this important food product is due to the following facts: Pure commercial glucose is practically unknown in household cookery, and so is not sold in a package convenient for household use. While it is in multifarious food products found on the grocer's shelves it is rarely seen there in its original state. This is equally true of raw sugar. Years ago, raw open-kettle sugars were familiar to all New England housewives and were used by them in cooking. Raw sugars made by modern processes are used to some extent in England and European countries, but nowadays few of the citizens of this country, outside of the sugar producing districts, ever see raw sugars, which are sent directly to the refineries in packages weighing several hundred pounds each and in a condition not fit for domestic use. Glucose, like refined sugar, is manufactured in comparatively few factories, and these of large capacity, for the manufacture of glucose requires a large outlay of capital and consequently large output. The cheapness of the product makes its manufacture profitable only on a large scale. This is equally true of sugar.

What is commercial glucose? In general appearance it is a transparent, very viscous sirup, often practically colorless but usually of a light straw color, sweet, but with little if any other flavor. For this reason, glucose, like sugar, has been termed a "neutral sweet"—not neutral in the chemical sense—although such products are always chemically neutral within practical limits of testing—but so called because when pure they have no characteristic flavor other than sweet and will take any added flavor unchanged.

Glucose is not made by use of oil of vitrol and chalk, nor is glucose, in the ordinarily accepted sense of dextrose, its characteristic ingredient. The trade name "glucose" while well established by custom of years is no more suited to the present product than is "chloride of lime" to bleaching powder or "hyposulphite of soda" to the commercial salt sold under that name. It is true that the basic process by which glucose is made from starch is on the lines of Kirchoff's original experiment, but the methods are quite different. The "starch milk," a suspension of the granules in water, is pumped into large pressure boilers of gun metal, and is cooked for about 10 minutes with a few tenths of a per cent of hydrochloric acid (commercial muriatic acid) under a pressure of about 50 pounds of steam. The starch is not treated long enough by this process to convert it entirely into grape sugar (true glucose), only about 20 per cent being produced. There is, in fact, less of the glucose sugars, properly so called, in commercial glucose, than occur as natural ingredients of cane sugar molasses, and far less than in honey, which is composed almost entirely of glucose sugars, nearly half of which is dextrose (grape sugar), this being the sugar which separates out when the honey granulates.

Commercial glucose as now made contains less than 20 per cent of true glucose sugars, the rest being a mixture of malt sugar (maltose) and dextrins, more or less in chemical combination in the approximate proportion of nine parts of maltose to seven of dextrin. In percentages of total sugars and dextrins, there are in round numbers—maltose, 45 per cent, dextrose, 20 per cent, dextrin, 35 per cent, the proportions varying somewhat in different lots.

These three carbohydrates: dextrose, which is a true glucose sugar; maltose, belonging to the [illegible]

* [illegible]

family, and making up nearly half of the total, and dextrin, a gummy ("colloidal") substance closely related to starch paste, compose over 99 per cent of the solid matter of refined commercial glucose. This composition has been found to be the most desirable for imparting to the product the properties most suited for a sirup which can be refined readily, and at the same time contain enough colloidal material to prevent its crystallizing at any concentration. This colloidal matter also renders the sirup capable of dissolving considerable amounts of cane sugar without crystallization. Such a product is peculiarly valuable in the preparation of sirups, candies, preserves, and jellies, quite apart from its use as a sweet. It also contains nearly the maximum amount of malt sugar that can be produced by such a process.

The rest of the dissolved substance of commercial glucose consists of 0.3 to 0.5 per cent of mineral matter, mostly composed of sodium chloride from the neutralization with soda of the hydrochloric acid used in the manufacture, sulphites which are added at various stages, phosphates and other salts from the natural mineral matters present in minute quantities in the starch or coming in part from the boneblack used in the refining process. There is also about 0.08 per cent of nitrogen corresponding to five or six times its weight of organic substances from the gluten left in the starch. Much of this nitrogenous matter is not gluten, but simpler organic compounds resulting from the action of the acid (used to convert the starch) on the gluten. These nitrogenous matters have much to do with the quality of the glucose, and it is on this account that they are of peculiar importance although present in minute amounts. The impurities from the gluten which are less acted upon by the acids, the "albumoses," give trouble to the candy manufacturer by causing foaming in his kettles, while this property is the joy of the brewer. Those gluten substances which are changed further by the acid, the "amino bodies," tend to make the glucose darken and also impart a flavor which though barely perceptible is disagreeable—bitter or fishy. Manufacturers used to correct the objectionable effects of these impurities by the addition of sulphites to the glucose but this was but a temporary expedient and undesirable in a food product. Glucose has been much improved in recent years by practically eliminating the effect of these impurities by more efficient purification of the starch used in its manufacture.

The glucose process does not end with the acid treatment of the starch and the neutralizing, as at this stage the dilute sirup is far from pure, containing oily matters from the corn, some undecomposed gluten and other impurities mostly in suspension. This liquor before it is concentrated to a sirup of about 80 per cent solids undergoes a refining with boneblack closely resembling that of cane sugar, the apparatus being practically identical—filtering through bags and boneblack filters—but in the case of the glucose all impurities affecting the quality of the sirup have to be removed or destroyed as there is no purification by crystallization.

Hence, glucose, like granulated sugar, is one of the purest food products in use, however pernicious the properties that may be ascribed to it.

Space does not allow a detailed description of glucose manufacture which is of great interest owing to the numerous by-products which are made, and also because while glucose is the chief in output, its manufacture is only one of many starch products carried on at the same time.

The following table, taken from an advertising circular of a manufacturer, shows in a concise way how the different parts of the corn kernel are utilized:

Parts of Corn Kernel	*Composition*	*Products*
1—Germ	Oil and Oil Cake	Corn Oil, Corn Oil Cake, Corn Oil Meal.
2—Endosperm (Body of the Corn)	Starch	Dry Starches, Dextrines, and, by conversion, Corn Sirups (glucose) and Sugars.
	Gluten	Gluten Feed.
3—Hull	Bran	Gluten Feed.
4—Water added for steeping	Soluble Substances of Corn	Gluten Feed.

The oil is used principally for soap and for making vulcanized products used for rubber substitute. The oil-cake and meal from the cake are used as cattle feed. The gluten and bran from the starch, mixed with the soluble matters extracted by the water used to soften ("steep") the grain before grinding is made into "gluten feed" also for cattle. All these are valuable by-products for which there is a good market. The starch in a moist state, known as "mill starch," is the raw material for making the various goods which are sold under the names of "glucose" ("corn sirup"); "corn sugar" ("grape sugar"), the latter a hard product which is largely composed of dextrose, but never known in trade as "commercial glucose," and little used as a food product; "dextrines," or adhesives which are usually made by roasting starch and entirely different in characteristics from the dextrin ingredient of commercial glucose; besides numerous "dry starches" used by laundries, confectioners and in many other industries as well as for household purposes.

At present prices, commercial glucose, a sirup containing about 80 per cent of the pure carbohydrates in solution sells at about 2¼ cents per pound (26-28 cents per gallon) or at about 2.7 cents per pound of actual dissolved substance. Is its sole use that of an adulterant of better food materials as some food reformers claim? Is glucose used to adulterate our ordinary grocery sugars?

It is well known in the history of the industry that some 30 thirty years ago a Chicago concern spent some millions of dollars and much valuable time in trying to adulterate fine grained white sugars with solid grape sugar of high quality, made from the starch, but the attempt failed miserably simply because the stuff would not stay mixed and the grains "set" in a solid mass after a short time. In years gone by, glucose was also much used to mix with cheap, poor grade molasses, making a brighter, more attractive product which, so improved, could be sold at the price of higher grade molasses. This form of adulteration is so easily detected that it is rarely resorted to in these days of pure food legislation. The last case which came to the writer's notice was one of a New York molasses dealer who was heavily fined for having a few per cent of commercial glucose in his molasses, although his defense was a plausible one—that some glucose was accidently left in the barrel, old glucose barrels being much used for tropical molasses shipments.

Glucose is now used in a legitimate manner to mix with cane-sugar sirup in the proportion of 85 per cent of glucose to 15 per cent of sirup, a little salt and sometimes vanillin being added to improve the flavor. The cane-sugar sirup is usually refinery molasses ("barrel sirup") which imparts the principal flavor. These mixed sirups are sold openly as glucose or "corn sirups" and as their flavor is superior to the original molasses there seems to be no reason why they are not wholesome food products for legitimate trade, even though some people there are who prefer the flavor of the sirups made from the natural cane juices and are willing to pay the higher price for such. Certainly, such glucose sirups are preferable to the average grocery molasses either from the standpoint of the epicure or the sanitarian.

Commercial glucose is used in large quantities in the manufacture of cheap jams and preserves. Apple cores and skins from fruit in its preparation for evaporation or preserving are the basis for most cheap jellies; the pectin substance and juice being extracted by the usual processes of jelly making and mixed with glucose and sugar, forms a jelly material to which other fruits are added. The law requires such jellies to be plainly described on the label so that the consumer is informed that he is using a jelly made of apple and glucose with a fruit flavoring, and is at perfect liberty to buy the pure glucose-free fruit product if he so prefers. What interests the public is: Are these cheap jellies unwholesome, or is there other reasons why the man with the slim pocketbook should not buy them? This question is quite apart from whether they contain glucose or not, but deals with the soundness and wholesomeness of the ingredients used and the cleanliness of their preparation.

By far the largest amount of glucose is consumed in the manufacture of candy, the peculiar properties of this sirup making it especially valuable in this industry, as has been explained. The requisite for most candy is that it should not "grain" (crystallize), and glucose, owing to its colloidal nature, is the most effective and wholesome substance to prevent this. The popular impression that glucose is used in candy-making because it is a cheap substitute for sugar and that its sole function is to give sweetness is only approximately correct.

How sweet is glucose relative to cane sugar? Determinations of the sweetness of a saccharine product are very unsatisfactory, owing to personal equation and also to the influence of the other mixed ingredients and even the physical condition of the substance tested.

Granulated sugar tastes sweet. Powder it in a mortar and it will taste less sweet. Owing to this fact it is hard to convince some people that powdered sugar is not adulterated, although this practice, easily detected, is practically unknown at present. A quarter of a grain of quinine mixed into a pound of granulated sugar is said to make it taste sweeter. Common salt in small quantities will improve the sweetness of cake and other sweet foods, as all cooks know. Raw sugars, even when they contain negligible quantities of the sweeter mother-sirups, taste distinctly sweeter than granulated sugar although their actual sugar content is less. This is due to the salts and extractive matter in the raw product, and it is why many cooks sigh for the old-fashioned open kettle sugar and even prefer the refiners' imitation goods to granulated in making their apple pies.

Relative tests of the sweetness of cane sugar and glucose (dextrose) have been made by dilution experiments on the pure sugars, but as far as the writer knows, no relative tests of the sweetness of commercial glucose as now made have been published. Taking this value to be 0.5 for the solids in glucose, sugar at 5 cents is cheaper as a sweetener than glucose.

As a matter of fact, very little candy is made with glucose as the only sweet. Usually, candy contains 60 per cent or more of cane sugar, the sweetening of the glucose being of much less importance than the other properties it imparts to the mixture.

It seems reasonable to infer that commercial glucose, rather than being a serious competitor of cane sugar, has really increased the consumption of the latter, especially in candies. Because of the great advantages from the use of glucose in candy-making, the industry has had an impetus which has greatly increased sugar consumption.

The relative wholesomeness of candies made from glucose and those made from cane sugar has never been decided, and may never be. The dextrins of "glucose" as now manufactured are in great part in combination with the malt sugar and seem in every way identical with the malto-dextrins obtained by the action of malt on starch, and are digested more in the intestines than in the stomach as compared with pure sugar candies. Whether this is an advantage or not, the physiologists must decide.

Glucose is extensively used in industries not making food products. It is used in cheap soaps, for "filling" leather and tanning extracts, and as many of its uses in such industries are apparently for adulteration, such practices have no doubt added to its reputation as the "champion adulterant." As was pointed out in an article in a previous number of *Science Conspectus*, No. 2, 1913, on the industrial uses of sugar, the highly respectable beet sugar of 99 per cent purity is used in Europe for precisely the same purposes, the choice between sugar and glucose as a "filler" being merely a matter of price. Cane sugar has also been used extensively to "fill" coal-tar dyes and adulterate chocolate without having its respectability seriously impugned.

In view of the undoubted commercial importance of glucose as a food product it would seem as if its value in dietetics and food economics, as well as its relative wholesomeness, ought to be studied in the light of a proper knowledge of its special characteristics. To call glucose "mucilage," or to ascribe to it properties of a dextrose solution is either ignorant or dishonest. As far as the use of glucose as an adulterant is concerned, it is the function of the Pure Food Laws to protect the public from these practices, and such obviously are quite apart from the legitimate and open use of glucose, sugar or any other cheap and wholesome food product as a satisfactory substitute for more expensive ingredients, and the propriety of such a substitute always will be its suitability for the purpose and its cost.

If legislation is appropriate for forbidding the extravagant claims of manufacturers and dealers as to the superiority of their food products, why not legislation to prevent irresponsible statements of "pure food" authorities which are condemnatory? Certainly, the one is fully as important for the public interest as the other.

Protecting Steam Boilers

In large steam power plants it is very desirable to keep a careful and constant watch on the feed water to guard against the entry into the boilers of any contaminating substance that might cause scale or irregularity of working, for it has been found that prevention in such cases is much cheaper than cures, both in regard to labor and in loss from interrupted operation. In one of the large electric generating stations in New York salt water is used for cooling the condensers, and to insure that none of it gains access to the boilers through a suddenly developing leak the condensed water is tested every hour by titration with nitrate of silver. This frequent testing is necessary because, in a plant of the size in question, it would be but a matter of a short time for a comparatively small leak to make a decidedly injurious addition to the feed water. Besides this test, the contents of the boilers themselves is also tested once a day as a check, but the principle dependence is placed on the scrutiny of the condenser water.

Luxembourg Bridge

The Adolph Bridge at Luxembourg is constructed on the designs of M. Séjourné, a prominent Paris engineer. His idea is to reduce the amount of masonry for a given width of bridge, for instance in a single-arch span, and to build two arches side by side with a space between them. Upon the pair of arches is laid a reinforced concrete floor. Span of the Luxembourg bridge is about 280 feet, and the platform is 135 feet above the level of the stream. Width, 52 feet. The structure cost $300,000, which is $50,000 less than the cost of a full-arch bridge of the same kind.

French surgeon inspecting his fellow prisoners in Germany.

A 42-centimeter shell.

Cripples working at trades by aid of artificial limbs.

An Exposition of Military Sanitation

Showing How the Sick and Wounded Are Cared for in This War

By Dr. Alfred Gradenwitz

An efficient sanitary service is a necessity to armies for humanitarian as well as practical reasons. It is, in fact, of the highest importance that patients should, if possible, be fitted to return to the firing line as soon as practicable, while those unable to resume fighting should at least be in a position to take up their pursuits at home, and not become a burden on the state. Humanitarian reasons are, of course, also taken into consideration, and private as well as public charity find ample scope for their patriotic endeavors in the interests of the immediate victims of war.

While strategy has, of recent years, undergone a profound revolution, sanitation has also made enormous strides, availing itself of all the latest achievements of medical and physical science as well as engineering.

The vast field of sanitation in all its various phases, as it is practised in the present war, is surveyed in a very attractive way by the Exposition of Military Sanitation being held at Berlin. This instructive show comprises not only all classes of sanitary equipment, models of means of conveyance and sanitary buildings, but a model about 12 meters long which represents a several days fight for a fortified town, thus affording an opportunity of illustrating in all its details the work of the sanitary corps in actual battle.

On entering the exposition we are at first struck by the *model of a ship hospital*, which, *in full size*, represents all the arrangements usual on war ships. Parts from the ships of the German navy have been used in mounting this model, the medical instruments and other utensils, as well as the chemist's shop, being likewise derived from the navy stores. The model illustrates the arrangements provided for peace and war use, showing, for instance, how the wounded are transported on staircases and through hatches, in a special hammock developed during many years' trials in time of peace. The dressing stations, equipped with all surgical implements are, of course, installed in those parts of the ships which are least exposed to the enemy's fire; the operating tables are provided with special damping devices allowing for the ship's movements. When an engagement is over, the remaining hospital rooms are, of course, available. Movable berths, adapted to the rolling and pitching of the ship, are used. Any seriously wounded are, however, at the earliest possible moment, transferred to some hospital ship or to a naval hospital in a harbor town.

Adjoining this section is the most important and extensive department of the exposition, where the sanitary service of the German army is illustrated in all its details by means of models and actual equipment as used in current practice.

As in all other modern armies, the sanitary service begins with the dressing package which every soldier carries about him, and which enables him at any time to apply a first dressing to himself or some wounded comrade. Whenever any further care is required the ambulance staff take charge of the patient. It would be too long to describe the whole mechanism constantly at work in receiving and evacuating patients. The most important phases of this service are, however, enumerated in the following:

Every large detachment, e. g., every infantry battalion, has a special staff and some material of its own, which is taken close to the firing line, and installed in a sheltered position. Such troops as are equipped with vehicles, e. g., the artillery, do not require any sanitary cars. Apart from these arrangements destined for rendering first help, each army corps includes three ambulance companies distributed in accordance with actual requirements, and which carry not only more abundant sanitary material, but a certain number of ambulance cars, as well as a supplies car and field-kitchen. The work of these ambulance companies is centered on a main dressing station, whence the men search the battle-field methodically. However, the wounded are, at the earliest possible moment, evacuated from these dressing stations; those only slightly wounded will often be able immediately to return to their division, while the balance are taken either to a convalescent camp or to a field hospital, of which each army corps has twelve. It being desirable to get these hospitals in readiness for any further work that may turn up at the earliest possible moment, a point is made of clearing them as soon as possible, patients being returned to the front, if their condition permit, or turned over to one of the larger hospitals in the line of communications or base. German practice in this war has so far been to send home as many patients as possible, to be treated either in some large hospital or in their families. This, in fact, not only prevents the hospitals near the theater of operations from becoming overcrowded, but exerts a most beneficial effect on the *morale* of the men.

Apart from stationary hospitals portable barracks are used to a large extent, in fact wherever no adequate buildings are available. These barracks, which are fully represented at the exposition, are readily installed, taken apart and conveyed to any place where their services may be needed without the aid of skilled workmen. Patients suffering from contagious disease are housed in special hospitals.

The arrangements used in transporting wounded and sick are likewise illustrated by actual outfits as well as models. While being used occasionally for the transport of sanitary material, X-ray outfits, etc., automobiles play a much more important part as a means of conveyance for invalids. Motor buses converted into ambulance cars are shown side by side with all the various systems of motor ambulances designed of late years.

Railroads and ships are, of course, mainly used in conveying the wounded from the theater of operations and the base to their respective home districts; wherever required, the German corps of engineers will install at short notice railroads for military use and for large scale invalid transports. Apart from improvised ambulance wagons, the arrangement of various systems of ambulance trains proper is illustrated on actual specimens and models. The distinctive feature of these systems generally is the elastic suspension of the beds.

The fighting of disease and epidemics in war is the object of another department of the exposition. When it is considered that contagious disease has, in most wars, wrought even heavier havoc among the armies than the projectiles of the enemy, the importance of this subject will be readily understood. Foremost among the means used in this connection should be mentioned the various sera, which have lately been developed to such importance, especially in the case of diphtheria, dysentery, meningitis, and quite recently, tetanus. The manufacture of these sera (mostly derived from immunised horses) is illustrated in two pictures, while a third shows the way of using meningitis serum. Prophylactic inoculation, not only against smallpox, but against cholera and typhoid fever—according to new processes successfully employed in the present war—is likewise illustrated by photographs and statistic tables. The divers processes of disinfection, of elementary importance in the fight with epidemics, are, of course, dealt with in great detail.

Realizing that tuberculosis is a factor of paramount importance in the state of health of a nation, and, accordingly, its aptness for military service, the army and navy have, for many years, bestowed especial attention on this disease. A special section of the department last named is therefore given up to the means of fighting tuberculosis and statistical returns on their effectiveness. Sufferers from tuberculosis are, of course, kept away, as far as possible, from the army and navy. Whenever the disease develops in course of service, patients are discharged and are, if necessary, placed in some sanatorium.

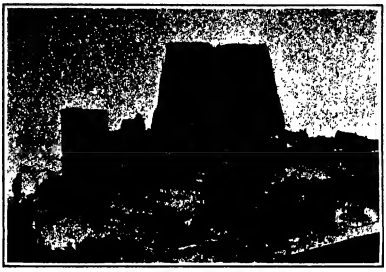
From this department we enter that given up to X-ray work. While being indispensable in general medical and surgical practice, X-rays play an especially important part in military surgery. In fact, even the smallest German army or navy hospital comprises a complete X-ray outfit, used not only in discovering and locating foreign objects but in watching the healing process of fractured limbs and allowing any displacement of the fragments to be effectually prevented. A number of special apparatus, transportable and portable outfits, etc., are on show.

Another section is devoted to the dentist's tasks in war. In the modern fortification war, the number of wounds of the head and, especially injured jaws, is particularly great, thus affording ample scope for dentist's work. On the other hand, there is the prophylactic treatment of otherwise healthy soldiers, a man suffering from toothache being practically useless from a military point of view, while the presence of lesions in or near the jaws, in the event of a wound, greatly increases the risk of infection. All these tasks are illustrated in a striking manner. We see the dentist at work in his improvised consulting room, with a most practical portable outfit, special kinds of dressing being demonstrated on models. The use of X-rays for the special purposes of the dentist is likewise shown.

We now enter the department illustrating the technicalities of nursing, which art has, especially of late years, undergone such a rapid development. The extensive material is distributed in accordance with scientific principles in ten cabins arranged alongside the walls. We thus acquaint ourselves with the means of bedding patients, the principles governing the dress of invalids and nurses, and the arrangements used to keep patients clean. In a fourth cabin, there are technical arrangements for the feeding of patients, and in a fifth one, those for administering medicine. The various means of opening a patient's bowels are found in a cabin of their own, as are the methods for warming and cooling patients. Apparatus for the active and passive motion of the sick and wounded and means of instruction in the technicalities of nursing are likewise on show. There is finally a special exhibition of all sorts of methods and devices for amusing and occupying patients.

Another most instructive department is that devoted to the care for cripples, where all the various means of preventing wounded limbs from becoming crippled are shown, both orthopædical apparatus and operative processes. The training of cripples for manual work is likewise illustrated, thus showing the solution of an urgent social problem. Two cripples are represented by life-size figures, one of whom, according to the old practices, plays the barrel-organ, whereas the other, an extreme case, though having lost both arms and both

Various methods of transporting the wounded.



Model showing effects of a bombardment.

legs, worked merrily away on the lathe. How this apparent miracle is wrought, what arrangements serve as artificial limbs and by what means the cripple is enabled to handle any tool with his mulitated arms, is fully illustrated. The German authorities are confident that all war cripples will be able to work at some craft, and not be dependent on charity.

Voluntary sanitation in war time—the organization and work of the Red Cross Societies and orders of knighthood—is represented in a mainly statistical department; and the last section allows the history of military sanitation from antiquity, through the middle ages, up to modern times to be studied from a large collection of historical objects and pictures.

Modern Theories of Gravitation*

UNIVERSAL gravitation still remains as mysterious as it was two centuries ago. Electrical, magnetic, and other physical forces are dependent on the nature of matter, and they can be subjected to influences that modify their intensity and effects, but universal gravitation, intangible and immutable, defies the art of the experimenter. The weight of a body does not change when the matter of which it is composed passes from one physical state to another, or even when it undergoes the most profound chemical alteration, and the acceleration of all bodies falling in a vacuum is exactly the same. No modification of the mutual attraction of two bodies produced by the interposition of a third body has ever been detected, and it must be admitted that gravitation can pass through the whole earth without being appreciably weakened. In a word, nothing in gravitation can be altered.

Electrical and magnetic forces exhibit a considerable analogy with the force of gravity. The attractions and repulsions of electrified bodies and magnetic poles obey Newton's law, and the same equations apply to these and to gravitational phenomena. The potential of gravitation and the electrostatic potential are defined in the same manner, and the equations of Laplace and Poisson apply to both. But can the analogy be carried further? In electricity an important rôle is played by the medium in which electromagnetic effects are propagated with the velocity of light. Is gravitation produced in like manner and propagated through the ether with a finite velocity, perhaps equal to that of light?

This question is of fundamental importance, for equal velocities of propagation of gravitational and electromagnetic effects would suggest a close relation between the two phenomena.

Several years ago H. A. Lorentz proposed an electromagnetic theory of gravitation, based on then recent discoveries concerning electrons. The fundamental equations of this theory contain the velocities of electrified particles, relatively to the ether. So long as two electrons are at rest their mutual action is given by Coulomb's law, but their movement introduces a modification which depends on the ratios of their velocities to tha of lihgt.

The new law of attraction differs from Newton's law by the inclusion of terms which depend on the motions of the bodies and can be developed in series of ascending powers of $\frac{v_1}{V}$ and $\frac{v_2}{V}$, in which v_1 and v_2 denote the velocities of the two bodies, and V denotes the velocity of light. The formulas obtained contain no terms of the first degree, and the terms of degrees higher than the second are so small that it will suffice to consider the terms of the second degree, i. e., terms containing

$$\left(\frac{v_1}{V}\right)^2 \text{ and } \left(\frac{v_2}{V}\right)^2$$

An important question is now presented. Do observed astronomical phenomena permit us thus to modify Newton's law? The ratio $\frac{v}{V}$ is about 1-10,000 for the earth, 1/8,600 for Venus, and 1/6,200 for Mercury. The effect of the terms which contain the squares of such small fractions is always exceedingly small and very difficult to detect. The longitude of the perihelion of Mercury is found to be subject to a secular variation which does not appear to be attributable to the attraction of the other planets. This is one of the rare phenomena which show discordance with Newton's law. Lorentz computes the secular motion of the perihelion at 4 seconds, which is about one tenth of the observed discrepancy. The motion may be due, however, to the attraction of a swarm of small bodies surrounding the sun. The existence of such a swarm has sometimes been assumed in order to account for the zodiacal light.

Lorentz abandoned his theory after the publication, in 1906, of Einstein's principle of relativity, with which the Lorentz theory of gravitation disagrees, in retaining the old laws of mechanics, and also in introducing the movement of the entire solar system relatively to the ether.

The momentum, or quantity of motion, of a body is usually defined as the product of its mass multiplied by its velocity, but in "relativist" mechanics this product, mv, is divided by $\sqrt{1-\frac{v^2}{V^2}}$, and the kinetic energy is mV^2 divided by the same factor. In these expressions v denotes the velocity of the body, V the velocity of light, and m may be called the "constant mass." It is often advantageous to introduce a "variable mass" M, obtained by dividing m by the above-mentioned factor. The momentum then becomes Mv, and the energy MV^2, plus a constant.

A relativist theory of gravitation has been developed by Poincaré and Minkowski. If we know the force exerted by a motionless body upon a moving body, the principle of relativity enables us to calculate the force acting on each body when both are in motion, and consequently to determine the motion of each body by means of the equations of relativist mechanics. The problem is not quite determinate, because the principle tells us nothing of the effect of a body's own motion on the force exerted on it by a body at rest. If we take the mutual action of two electrons as a model, we are led to conclude that the force thus defined is independent of the velocity and reduces to the Newtonian attraction. On this hypothesis De Sitter has computed the variations in the elements of planetary orbits and has found 7 seconds for the secular motion of the perihelion of Mercury. This result is due entirely to the new definition of momentum, and involves no modification of Newton's law, so far as the force acting on the planet is concerned.

Einstein's theory of gravitation differs from the preceding theory in that it leads to a force differing slightly from the Newtonian attraction, even for a planet at rest. Its point of departure is a very remarkable deduction from the principle of relativity. As the kinetic energy is equal to MV^2, plus a constant, it follows that every variation in the kinetic energy involves a variation in M, the "variable mass," which may be expressed by saying that energy itself possesses or represents a certain mass. Hence the weight, if it is proportional to the mass, is likewise increased by any increase in the kinetic energy, and all kinetic energy (that of radiation, for example) possesses weight.

Also, to say that a material point is acted on by a force is equivalent to saying that its momentum is changing. As the motion of momentum has been extended to electromagnetic waves, it follows from the preceding considerations that the velocity of light is not the same at every point of the field of gravitation.

If a body acquires a velocity u in falling from one point to another under the influence of gravitation, the velocities of light at those two points should differ, according to Einstein, by about $\frac{u^2}{2V}$.

This is Einstein's theory of gravitation in its first form. His incessant efforts to improve it have resulted in the admirable theory which he has recently published, in collaboration with Grossmann.

In this improved and very complex theory, a field of gravitation is characterized, not by a single potential, but by ten parameters which depend, in general, on the geometrical co-ordinates and the time, and whose variations determine all the effects of gravitation. The application of the theory, however, is simplified by the fact that many of the terms are too small to produce observable effects. One of the ten parameters is predominant, taking the place of the single potential of the old theory and the variable velocity of light of the provisional theory.

The improved theory leads to the conclusion that gravitation is propagated with the velocity with which light moves in the absence of a gravitational field. The expression for the attraction exerted upon a planet by the sun contains, in addition to the principal terms corresponding to Newton's law, terms of the second order of magnitude that depend on the planet's motion.

Einstein has pointed out some results of the theory that may, perhaps, make it possible to observe almost directly the variation of luminous velocity in a field of gravitation.

First: A luminous pencil should be curved by the influence of weight. The change of direction would be quite insensible to the terrestrial, but very much greater in the solar field. Einstein calculates that a ray of light coming from a star and grazing the sun's surface would be bent inward by 0.83 second, increasing by that amount the apparent angular distance of the star from the sun's limb. This effect might possibly be observed in a total solar eclipse.

Second: If light coming from two sources of different heights is examined with the same spectroscope, the spectral lines of the higher source should be a little nearer the violet than the corresponding lines of the lower source. This effect also is absolutely inappreciable in the terrestrial, but not in the solar field. For two similar molecules, situated respectively on the sun's surface and at the earth's distance from the sun, the difference is about one hundredth of an Angstrom unit. Hence, the Fraunhofer lines of the solar spectrum should be nearer the red, by this amount, than the corresponding lines of a terrestrial source. Displacements of this order of magnitude have actually been observed. They have been attributed to effects of pressure and movement, but they may be due to the cause indicated by Einstein.

The only important difference between the electromagnetic and gravitational fields is that the former is determined at every point by six parameters (the components of the electric and the magnetic force), and the latter by ten. In each case the field is the seat of momentum and energy which it can impart to, or receive from, matter. It is quite possible to regard both fields with all of their properties as consisting of different modifications in the internal condition of the same ether.

* From an article in *Revue des Sciences*, based on an article by Lebedev, in *Scientia*.

Salts Colored by Cathode Rays*

Their Peculiar Characteristics, and an Endeavor to Explain the Phenomenon

By Prof. E. Goldstein

If cathode rays fall on certain salts—for example, common salt, or chloride of potassium, or potassium bromide—vivid colors are produced immediately on these salts.[1] Thus common salt becomes yellow-brown (like amber), potassium chloride turns into a beautiful violet, potassium bromide becomes a deep blue color quite like copper sulphate. Here you see a specimen of common salt transformed in this way on the surface of the single crystals into a yellow-brown substance. I show also sodium fluoride, which takes a fine rosy color.

The colors so acquired in a very small fraction of a second may be preserved for a long time, even for many years, if the colored substances are kept in the dark and at low temperatures. But in the daylight, and also under heat, the colors will gradually disappear until the original white condition is reached again.

The colors of different salts are sensitive to heating in a very different degree. I could show you the yellow sodium chloride, prepared some months ago in Europe, but I cannot show you here the violet KCl and the blue KBr, because these colors, even in the dark, do not stand the heat of the equator. The same salt, if dissolved, may keep very different colors, according to the medium in which it has been dissolved, even when the pure medium itself cannot be colored at all by cathode rays. I am speaking of *solid solutions*, produced by fusing a small quantity, for instance, of common salt or of certain other alkali salts, together with a great mass of a salt which remains itself colorless in the cathode rays, as, for example, the pure potassium sulphate. Lithium chloride acquires a bright yellow color in the cathode rays; but if dissolved in potassium sulphate a lilac hue is produced, as you may see in this specimen. Likewise the pure carbonate of potassium acquires a reddish tint, but after dissolving it in the potassium sulphate it becomes a vivid *green* in the cathode rays, as you see here.

Very small admixtures are sufficient to produce intense colors. So 1/25,000 of carbonate will produce the green color in the potassium sulphate; even 1/100,000 gives a marked color, and an amount of certain admixtures, which I estimated as 1/1,000,000 only, may produce a slight but quite perceptible coloration in some salts. So if you work with potassium sulphate which you obtain from chemical factories guaranteed as chemically pure, you may observe a set of different colors in these preparations under the cathode rays, by which you will detect the nature of the different small admixtures which adhere to the pretended pure preparations of the different factories. In this way a new analytical proof, much more sensitive than the ordinary chemical methods, is obtained, and impurities may be detected even when a certain specimen of salt contains more than a single impurity, because the colors produced by different admixtures generally disappear with different speed in the daylight or under rise of temperature. For instance, the ordinary potassium sulphate turns to a dark gray with a single greenish tint at first. After a short while the very sensitive gray will disappear, simply under the ordinary temperature of the laboratory room, and a vivid green comes out. The gray hue indicates a very small amount of sodium chloride, 1/100,000 or so, and the remaining green indicates the admixture of a carbonate. Here are some preparations of potassium sulphate, each containing a single small admixture (K_2CO_3, Li_2CO_3, LiCl, KCl, KBr). You will notice how different are the colors of the originally white substances, varying from green to bluish-gray, ash-gray, grayish blue, and violet.

By fractional crystallization one may finally get a really pure preparation of potassium sulphate, which is no longer colored by cathode rays (or only in a very slight degree, indicating minimal traces of sodium chloride). But there are other preparations which, so far as I know, cannot be acquired in pure conditions by any means, not even by fractional crystallization. I never came across a pure sodium sulphate—the purity exists only on the manufacturers' labels. Even the best preparations of this salt contain an amount of sodium carbonate which up to the present cannot be separated from it, not even by frequent fractional crystallization. The color produced by the small admixture, which always remains, is a very marked ash-gray. By an intentional further addition of sodium carbonate the color becomes nearly black.

The question arises: What may be the cause of these colorations in pure salts and also in solid solutions of them? Shortly after the colors of the alkali salts had been discovered, an explanation was given,[2] according to which the phenomenon mainly consists in a chemical reduction. For instance, in the case of potassium chloride the chlorine would be set free, while the remaining potassium is dissolved in the unaltered main quantity of the salt, coloring it at the same time. And it seemed a convincing proof for this theory when Geisel[3] and also Kreutz, simply by heating rock salt in the vapors of sodium or of potassium, produced colors in this rock salt quite similar to those produced by cathode rays. It seemed that the problem was settled finally. However, it was soon discovered that the colored Giesel salts, although they look to the eye quite like the cathode-ray salts, in all other respects behave quite differently. For instance:

(1) The cathode-ray salts, as I mentioned before, are very sensitive to daylight: after an exposure to diffuse daylight of a few minutes, or in some salts even of several seconds only, the coloration diminishes, while the Giesel salts remain unaltered even when they are kept in full sunshine for days or even weeks.

(2) The cathode-ray salts, if dissolved in distilled water, show absolute neutral reaction; the Giesel salts are strongly alkaline.

(3) The cathode-ray salts give very marked photo-electric effects (as Elster and Geitel[4] observed); the Giesel salts are quite ineffective.

(4) In certain circumstances, which will be mentioned further on, the cathode-ray salts may emit a phosphorescent light, the Giesel salts none at all. Therefore the question arose again, Whether there is not a marked internal difference between the cathode-ray salts and the Giesel salts, and what is the nature of the latter?

I have succeeded in settling this question, having produced salts *by cathode rays*, the behavior of which is in every respect *absolutely identical with that of the Giesel salts*. You may produce such substances if you allow the cathode rays to fall on the original salts not for a short moment only, but for a somewhat prolonged time, *until the salts are strongly heated*. Produced in this way the salts will keep colors; but the substances colored in this way are *not* sensitive to light; they show no photo-electric effect; they give *strong alkaline* reaction, and they are not suited for phosphorescence—all like the Giesel salts. It is quite sure, and you may test it also directly by spectroscopic proof, that in this case, if, for instance, you have worked on sodium chloride, *the chlorine is set free*. Then, of course, an amount of free sodium is left, which dissolves itself in a deeper layer of unaltered sodium chloride, to which the cathode rays could not penetrate. I call these non-sensitive colors *the after-colors of the second class*, while the ordinary sensitive after-colors, produced in a short time on cool salts, are called after-colors of the first class.

Now, if the after-colors of the second class are identical with those of the Giesel salts, then, of course, the very different substances of the first class cannot be also identical with the Giesel salts. Therefore the question arises anew, What is the nature of the first-class after-colors?

One observes with regard to solid solutions that the first class colors depend not only upon the *metal* contained in the small admixture, but they vary greatly, for instance, in the case of the admixture consisting of potassium chloride or bromide or iodide. This indicates that the metals alone do not cause the after-colors. It becomes much more clear when we expose some ammonium salts to the cathode rays. (The ammonium salts are cooled by liquid air in the discharge-tube to prevent their evaporation.) Then you get strongly marked after-colors likewise; for instance, ammonium chloride becomes yellow-greenish, the bromide becomes yellow-brown, the iodide becomes brown, and the fluoride a deep blue. In the daylight these colors are gradually destroyed, quite like other after-colors of the first class. The colors themselves—yellow-greenish for the chloride, yellow-brown for the bromide, and so on—induce us to presume that the after-colors in this case are produced by the haloids, and not by the hypothetical ammonium radicle. This presumption becomes a strong conviction when we observe that also a great number of organic preparations which contain no metal at all (and not any metal-like radicle) acquire marked after-colors of the first class in the cathode rays also. (The part of the discharge-tube which contains the organic substances is cooled by liquid air.)

Then you may observe that solid acetic acid ($C_2H_4O_2$) remains quite colorless in the cathode rays; but if you substitute a hydrogen atom by chlorine, the substance thus produced (the monochloro-acetic acid) acquires a marked yellow-green after-color. If you introduce an atom of bromine instead of chlorine, you get $C_2H_3BrO_2$, and the after-color is of a marked yellow. Bromoform ($CHBr_3$) turns into the color of loam, and chloral (C_2HCl_3O) becomes a deep yellow. In this way we see that not only salts, but likewise substituted acids, substituted hydrocarbons, and substituted aldehydes acquire after-colors if they contain any haloid.

Now, it seems highly improbable that in the case of alkali salts the electro-positive component is absorbed only (producing the after-color), and that, on the other hand, in the ammonium salts and in the organic substances the electro-negative component is efficient only. The most probable inference is that in each case *both* components remain and that both are efficient, but that under the same conditions the haloids produce a slighter color than the metals, so that in the case of the salts the haloid color is overwhelmed by the metal color.

Therefore we are compelled to suppose that we have not to deal with a decomposition in the ordinary form, by which the different components are finally separated from each other and at least one of them is set entirely free, but that the components detained by absorption remain at a quite short distance from each other, so that they may easily meet again. I realise that, for instance, in the case of sodium chloride, at every point of the colored layer there is an atom (or perhaps a molecule) of chlorine and an atom (or a molecule) of sodium; but they cannot combine, because they are fixed by absorption and distended from each other by the absorptive power, which in this case surpasses the chemical affinity. But the absorptive power may be weakened by heating and the chemical affinity or the amplitude of the molecular vibrations may be strengthened by the energy of daylight.

If we grant these assumptions, it is immediately evident why the reaction of all dissolved color substances of the first class is a neutral one, for the two components may combine again and re-establish the original substance. The other special qualities of the first-class colors, and especially their differences from the Giesel salts, which contain the electro-positive component only, may be deduced likewise from this retention of both components and their opportunity of meeting each other again when the absorptive power is weakened or the chemical affinity is strengthened. Now, the two components in the colored substances being distended in some degree, I propose for this special condition of matter the name of *distension*. If we accept this, have we created a new name only, or does matter in this condition really show new qualities? It seems to me that we have to deal with a peculiar condition of matter, which deserves a more elaborate study than it has met until now. I will enter again into some special qualities, which have already been mentioned—the photo-electric effect and so on—but I should like to point out that matter in the distension state shows a strongly strengthened absorption of light.

We noticed with regard to ammonium chloride the yellow-greenish after-color of the chlorine. Now, cathode rays, as used in these experiments, will not penetrate any deeper than one-hundredth of a millimeter into the salt. In such a thin layer even pure liquefied chlorine would not show any perceptible color. But besides this it must be noticed that we observe this after-color at the temperature of liquid air, and that chlorine at this temperature, as Dewar and Moissan observed, is snow-white, even in thick layers. In a similar degree the brown color of bromine is weakened at low temperatures. Now, if nevertheless we observe at this very low temperature the marked characteristic colors of chlorine and bromine, we must conclude that the absorptive power of these substances has become a multiple of its ordinary value. One may observe this strengthening of the absorptive power directly in the pure sulphur. Sulphur likewise turns into a snow-white substance if cooled by liquid air. But when the cathode rays fall on the white sulphur it takes immediately a yellow-reddish color. It is a real after-color, because at constant low temperature the color is destroyed by daylight.

* A paper read before Section A of the British Association at the Australian meeting.

[1] E. Goldstein, *Wiedem. Ann.*, liv, 371; lx, 491; *Phys. Zeitschr.*, iii, 149; *Sitzungsber. Ber. Akad. d. Wiss.*, 1901, 222.

[2] E. Wiedemann and G. C. Schmidt, *Wied. Ann.*, liv, 618.

[3] F. Giesel, *Ber. D. Chem. Ges.*, xxx, 156.

[4] J. Elster and H. Geitel, *Wied. Ann.*, lix, 487.

Now, since the strengthening of light absorption occurs in this elementary substance, it becomes evident that the cause cannot be any chemical process, but only a physical allotropy. The special character of this allotropy (which may be connected with an absorption of electrons) will not be entered on in a discussion here. Probably we have to deal with a polymerisation, so that, for instance, the yellow-reddish sulphur would be analogous to polymerised oxygen—to ozone.

I have mentioned already that the first-class after-colors are gradually destroyed by incident daylight. A peculiar phenomenon is connected with this destruction of color. I found that after the daylight had fallen on the colored substances, even for the shortest time, most of them showed a marked phosphorescence of long duration. I have observed this phosphorescence even in substances which had been colored twelve years ago and had been kept in the dark since that time. The diffused dim light of a gloomy November day, when falling through a window on the colored substance for one or two seconds only, is sufficient for the production of this phosphorescence in a marked degree. If you allow the daylight to fall several times on the same spot, then the color is weakened at this spot, and we come to the presumption that the loss of coloration is generally attended by the emission of phosphorescent light. This is in accordance with the experience of Wiedemann and Schmidt that if the destruction of the color is produced by heating, likewise a phosphorescent light is produced, which in this case is strong but of a short duration, corresponding to the quick destruction of the after-colors by strong heating.

If the salts, after having been colored in the condition of a fine powder and then having been put between two glass plates (in order to obtain a plane surface), are placed in a photographic camera instead of the photographic plate, you may get a fine phosphorescent picture of a landscape or of architecture after a very short exposure. Time does not allow me to mention in detail several other peculiarities which are shown by matter in the distension state. In one direction only I may be allowed to make some remarks.

The first-class after-colors may be produced not only by cathode rays, but also by the β rays of radio-active substances, as you probably know. But they may also be produced by *ultra-violet light*, for instance, by ultra-violet spark light, even when a quartz plate is interposed between the spark and the salt. More than thirty years ago I brought forward a hypothesis, according to which in every point where cathode rays strike a solid body a thin layer of ultra-violet light-radiating molecules is produced in the gas, to which ultra-violet light of very short wave-lengths, for instance, the phosphorescence of the glass walls in the cathode rays, is due. But I came further to the assumption that nearly all effects which are commonly ascribed to special qualities of the cathode rays, and likewise of β rays, are mere effects of the ultra-violet light which is produced by the stopping of these rays. I have been guided by this assumption during many years, and have very often been aided by it in foreseeing new phenomena. For instance, in this way I was induced to expect that the after-colors would be produced not only by cathode rays, but also by the ordinary ultra-violet light; further, I could guess that also the X-rays would produce after-colors (which in this case have been observed by Holzknecht), and in recent times I could foresee that solid aromatic substances (the benzine derivatives) in the ultra-violet light must change their spectra of ordinary phosphorescence, composed of broad bands, and turn to peculiar spectra composed of narrow stripes, the wave-lengths of which are characteristic of the single aromatic substances.* So I believe also that the after-colors are produced not directly by the cathode rays or by β rays, but by the aforesaid ultra-violet light which is connected with the stopping of the other rays.

In this way the after-colors enter at once into a great class of phenomena known as *reversible effects of light*. You know that certain effects of the visible spectral rays are destroyed by rays of longer wave-lengths, by the infra-red rays. And the analogy to this phenomenon is, in my opinion, the destruction of the after-colors: they are produced by the ultra-violet light of the stopped cathode rays and are annihilated by the longer visible wave-lengths of daylight. In this way you may likewise understand, for instance, that the colored spots, produced by X-rays on the luminescent screens after long exposure, may be destroyed again by exposure of the screens to daylight. You may also explain the peculiar medical observation that therapeutic radium effects in parts of the human body not covered, specially in the face, are often not of long duration, for the face is exposed to the counteracting visible rays of daylight.

We notice here a connection of our subject with a department of great practical importance. For all therapeutic effects of X-rays, radium rays, and mesothorium rays would, according to this view, be effects only of ultra-violet light produced by the stopping of these rays in the human body, and the special character of the radium- and mesothorium and X-ray treatment would consist mainly in the carriage into the interior of the body, by the rays, of the ultra-violet light, which is not confined to the surface of the body, but is produced at every place where any of the entering rays are stopped. You may notice further that this view of the medical ray-effects presents a heuristic method for the treatment itself, which up to the present followed quite fortuitous and merely empirical paths. For it may be hoped that treatment by radio-active substances will be useful in every disease in which ultra-violet light has been proved to be efficient in some degree; you will avoid such treatment in the well-known cases in which light of short wave-lengths is noxious, and you may be justified in substituting an ultra-violet light treatment where radium or mesothorium is not obtainable. At the same time it becomes evident why the treatment of certain diseases by the β rays has effects very similar to those produced by *fulguration*, that is, by the light of very strong sparks; the efficient agent is in both cases the ultra-violet light.

But it cannot be a physicist's task to enter too far in medical questions; it was only my intention to show how interesting are some of the problems which are connected with the salts colored by cathode rays.

* E. Goldstein, *Verhandl. d. D. Physik. Ges.*, xii

Mutation and Modification of Bacteria*

A Knowledge Which is Important to the Recognition of Species and Kinds

By Sir Ray Lankester, K.C.B., F.R.S.

Ever since we gained (in the later half of last century) a knowledge of the ubiquity and importance of the minute plants called bacteria—as the agents of various "fermentations," including putrefaction and disease—the inquiry has been pursued in various laboratories, under the guidance of various able observers and experimenters, as to whether the "kinds" of bacteria which we can distinguish from one another by their shapes and structure as seen under the microscope and by the different chemical changes, fermentations and diseases to which they give rise, are always distinct "species," as are, for instance, the different "species" of a group of plants—say, the carrot-like family or umbelliferae. This family presents an enormous number of kinds which breed true and, though in a general way, much alike in appearance, yet having each its own form and producing each its own peculiar chemical substances in its juices. Some of these kinds or "species" are valued by us for flavor, as, for instance, celery, samphire, chervil, fennell, parsley, anise, and coriander; while some, such as hemlock, cowbane, and others of the group, are highly poisonous. Do the "kinds" of bacteria breed true as these higher plants do, or can they be largely changed by the influence of light, temperature, moisture, and the nature of the food to which they gain access? The answer to this question has obvious importance in regard to the origin of those diseases which are caused by bacteria.

Closely fitted as most higher plants and animals are to one set of conditions of existence—the change of which leads to their death—yet there is a certain range of toleration, varying in different cases. And sometimes the change tolerated has no obvious effect in altering the plant or animal subjected to the changed conditions; sometimes it results in a change of either the obvious structure or of the more subtle chemical activities, and sometimes of both. Thus some plants, such as the water-hemlock, which are poisonous when growing in marshy, wet land, cease to form a poisonous product when grown in dry soil. The wood of the English oak when grown at the Cape is worthless. Hemp and flax flourish and seed well in the plains of India, but their fibres are brittle and useless. The common rest-harrow when grown in marshy land is devoid of spines, but on a dry soil produces large sharp thorns. The leaves of the white water-buttercup when growing in water are totally different from those of specimens growing on the pond side.

It is, therefore, no exceptional or unexpected thing that a given kind or example of the simple thread-like or rod-like bacteria should be caused to change either in its shape or in its chemical activity and products when the conditions in which it is growing—such as exposure to light, heat, moisture, and various sorts of nutriment—are changed. And, indeed, this has long been a familiar and well-established fact. Some kinds of bacteria seem to be more liable to respond to changes of condition by consequent change in their own form and properties than others. In 1873 I described, under the name "Bacterium rubescens," a peach-colored bacterium which is very common in the decaying vegetable matter of ordinary ponds and rivers and also of salt marshes. I showed that it takes several different forms, namely, (1) rods of various shape, (2) filaments, and (3) minute spheres and ovoids of various sizes, variously aggregated or set together in a jelly or a film of definite pattern, or else freely swimming, according to the nature and abundance of the nutrition supplied to it, and other conditions. It has also been shown to take on a corkscrew shape. I called it a "protean" species, and subsequently this doctrine of the "pleomorphism" of bacteria, a term referring to the multiplicity of shapes which can be assumed by many kinds under diverse conditions, was adopted by Zopf and other writers, and it is now regarded as based on established fact. Some kinds are much more limited in shape and more intolerant of change of conditions of existence than others.

The change of chemical activity of bacteria by change of their conditions of life was first demonstrated and made use of by the great investigator of bacteria, the chemist Pasteur. He found in 1880 that the rod-like bacillus anthracis, taken from the blood of sheep which have died of the disease called "anthrax" in consequence of its presence, can be cultivated on chicken-broth in the laboratory, and that if plenty of oxygen be passed over the surface of the broth and it be kept at a temperature six or seven degrees above blood-heat, the properties of the bacillus are altered after a few hours' growth. It is no longer capable of producing the disease "anthrax" when injected into an animal, not even in a mouse! It has lost its virulence; that is to say, its former special chemical activity. But Pasteur found that animals inoculated with these "attenuated" bacilli proved, subsequently and in consequence, to be completely resistent to the deadly effects of non-attenuated bacilli of anthrax when injected into them. Thus was started a method of protecting sheep and cattle against the deadly disease "anthrax," which on the Continent had been a very serious trouble to farmers, and is now kept in check by Pasteur's inoculation. It was soon discovered that by transferring a disease-causing bacterium or bacillus from one species of animal, in which it was deadly, to another more tolerant of it, the "microbe" (a convenient term for the living "germ," whether bacillus, coccus, or other microscopic organism) could in many cases be "attenuated" that is to say, its virulence could be reduced. Thus the protection afforded by "vaccination" to small-pox was explained—the small-pox microbe of man becoming attenuated in bovine animals yet serving to render human beings when inoculated with it resistent or "immune" to its poisonous action. The consideration of the theory of this protective action would take us far from the present subject.

A number of cases have been studied in which the chemical activity of bacteria, as tested by the production of recognizable chemical compounds, is altered by culture. The most abundant bacterium in the contents of the intestine of man and animals, called bacillus coli, has been studied in regard to its power of attacking various kinds of sugar (lactose and glucose) forming acids, liberating gas, and also producing indol when grown on broth. In these respects it acts differently from the "Bacillus typhosus," which is closely similar in form to B. coli, but can do none of these things, and is the cause of typhoid fever. By cultivation of bacillus typhosus on a film of agar jelly, to which the sugar called "lactose," or sugar of milk, was added, various strains of bacilli, with modified properties, have been obtained by a series of investigators. The most important result is that, though B. typhosus cannot ferment lactose, yet after continued cultivation in its presence strains of the cultivation are obtained which actually develop this power, and closely resemble bacillus coli. It seems that the milk-sugar eventually acts on B. typhosus, so as to convert it into B. coli.

* From The London Daily Telegraph.

Recently, moreover, Mr. Cecil Revis has experimentally determined (according to his papers published by the Royal Society) marked changes in cultivations of bacillus coli, the purity of which he insured by growing them from a single isolated bacillus, so that there could be no question of the accidental mixing of other kinds in the culture. The same principle of growing a crop of the microbe to be studied, from a single individual, was introduced by Pasteur, and subsequently carried out by Hansen in the investigation of beer-yeast. Mr. Revis cultivated his pure bacillus coli in broth, containing milk-sugar, at blood-heat, and added a small percentage of a chemical called "malachite green" to the broth; in another series of experiments he added "brilliant green." His object was to see whether small quantities of these more or less poisonous chemicals would alter in any way the form and activity of the growing crop of bacillus coli. The green dyes have come into the hands of students of bacteria, in connection with the method of study, which depends on staining these microbes either after death or during life, and many varieties and different colors of these complex chemical dyes have been used. One of these "greens" happens to be described by chemists as the sulphate of tetra ethyl-diamino-triphenyl-methane. It is not an easy name to remember, and there is no reason why anyone should try to do so. But it might be used to mystify the unlearned as successfully as an invocation of "the ultra-violet rays." Mr. Revis found that the effect of the presence of a little "malachite green" was that a culture of the bacillus coli was produced which was neither in its activities, nor in its form, nor in its mode of growth, a true B. coli, but greatly altered. It had completely lost the power to produce gas, and never regained it. When he used a trace of brilliant green (called also ethyl green) two distinct strains arose in his culture—one *A* modified in form, and retaining in subsequent growth the same modified form, the other *B* undergoing increasing change in continued cultivation, and resulting in a completely different organism. *A* was very small, *B* was relatively large and branching; *A* coagulated milk after seven days' growth, *B* in two days; *A* fermented a certain sugar after twenty days' growth in its presence, *B* not at all. These statements will serve to give some idea of the kind of facts which have to be observed in the pursuit of this question of the alteration of bacteria and bacilli by change of conditions, and it becomes evident that there is no reason for surprise that the ultra-violet rays (which are known to be those rays of the solar emanation which especially excite chemical changes in organic substances, and hence are often called the "chemical rays," as opposed to the "heat rays" at the red end of the solar spectrum) should excite changes in the growth and properties of bacillus anthracis similar to those excited by traces of disturbing chemical drugs.

The various chemical products manufactured by bacteria are thrown out by them into the infusions, solutions, and broths in which they live. Some, such as those which are poisonous and disease-producing, can only be recognised and their variation estimated by inoculating animals with them and watching the result; others are recognized by their smell; others by their production of color, and even of "phosphorescent" light; others by the special chemical fermentations which they excite, and can be precisely measured and distinguished by the analytical chemist. The fact that the peculiar smells and odorous products accompanying bacterial growth are due to the bacteria themselves and not to the kind of material on which they are nourished is demonstrated by the interesting fact that when cultivated in a pure odorless solution of tartrate of ammonium the putrefactive species of bacteria produce an offensive smell of putrescence, although no organic matter is present. Similarly many bacteria produce brilliant colors—red, yellow, green, and blue—due to chemical compounds which they form and throw out, and these are produced freely in colorless solutions of tartrate of ammonium as readily as when the bacterium is growing on animal or vegetable refuse. My bacterium rubescens is an exception in the fact that the peach-colored pigment which it produces is not thrown out, but remains in the substance of the bacterium and colors it. The coloring matter is called "bacterio-purpurin," and appears to act somewhat in the same way as chlorophyll or leaf-green, assisting the bacterium in its chemical work under the influence of sunlight.

One of the most remarkable color-producing bacteria is that which occasionally appears in large masses on bread, and, since it looks like blood, has on some occasions caused superstitious fears, and even panic (recorded in the legend of the Bloody Host, due to the invasion by this bacterium of the holy wafer). It is known as "bacillus prodigiosus." Races of it occur which are colorless, and from these color-producing races may proceed, when cultivated, some darker, some lighter. It appears that the addition of certain salts to the matter on which the B. prodigiosus is growing leads to the production of white races, and also of dark red races, which are permanent—that is to say, the chemical capacities of the organism are permanently affected.

Another feature in which bacteria vary owing to variation of conditions is in the production of "spores"—minute oval bodies capable of resisting desiccation, and even the heat of boiling water. Only a few bacteria are known to produce these resisting spores (the hay bacillus and the anthrax bacillus are among them), and these kinds sometimes give rise to a changed race or growth, which ceases to produce spores. It is not known what conditions cause this loss of the spore-producing quality, nor whether, when once lost, it can be reacquired. We thus see that there are a number of changes of form, chemical activity, and other important features which a kind or species of bacterium may suddenly exhibit when subjected to change of conditions and surrounding agencies. They all require—and are receiving—further study, in order that their real causes and nature may be understood in the fullest detail, and it is rather absurd to print telegrams in the daily papers about each little fact concerning them as it comes to light.

Some of these alterations or changes are more persistent when once brought about than are others. In some cases the altered bacterium goes on multiplying for as long as it is kept under observation in the laboratory without reverting to its original condition; in other cases it soon reverts, or, on the other hand, may vary still further, and so from one original stock we may obtain three or four more "modified" or "altered" strains, more or less persistent.

It is difficult, perhaps not possible, to compare these changes in bacteria with the variations which arise in the many-celled higher plants and animals. Some variations appearing in higher organisms are passed on to a new generation produced by sexual generation, that is, by the fusion of an egg-cell and a sperm cell; but when a change of some part is caused merely by the direct action of a change of external agencies, it is not passed on to a new generation which is no longer acted upon by that external agency. The bacteria do not reproduce by egg-cells fertilized by sperm-cells, but by simple continuous growth and division, or breaking of the parent into two. Hence the change of constitution produced by changed external conditions is in them more likely to be continued, since the new growths or generations are merely bits of a single minute parental individual which has been more or less profoundly altered throughout its substance. But when we have reproduction by fusion of two small reproductive particles thrown off from two distinct massive parents, it is clear that a change brought about in one parent by conditions which acted on it, but did not act on the other parent, may very well be obliterated by the fusion of its reproductive particle with that of the other unmodified parent (the "fertilization," as it is called, of the ovum by the sperm). And this is the more likely to hold when the modification or change produced by some new external agency is one affecting only a small part of a large, massive plant or animal, and not one altering the parent's entire substance, as is the case in the modified microbe or bacterium. Hence, though the knowledge of these changes in bactria is important in regard to the proper recognition of species and kinds among them, and as to their permanence and derivation or distinctness from one another, we cannot maintain that it throws any light at present on the disputed views put forward by De Vries and others as to the frequency and importance of two kinds of variation (mutations and fluctuations) in sexually reproducing plants and animals. Nor can it be applied to the disputed question as to whether innate or "blastogenic" characters originating in the germ alone are transmissible while acquired changes superinduced on the body (somatogenic character) are not so. There is in the bacteria no distinction between the "germ" and the "body." All we can at present say is that these microbes are liable to undergo, as the result of changed conditions, structural and functional changes, which are in some cases evanescent and in some cases more persistent; but to what extent persistent and why more or less so, we do not yet know.

Those who desire to know more in detail the results and tendencies of recent studies and experiments on bacteria should compare the article on bacteria written by me in Watt's "Dictionary of Chemistry" in 1888 with the masterly essay on bacteriology by the late Prof. Marshall Ward and Prof. Robert Muir in the "Encyclopædia Britannica" in 1910. Twenty-five years ago I wrote in the article above cited: "We have to expect the most important advances in the future from the endeavors of bacteriologists experimentally to breed by change of conditions one kind of bacterium from another, and even to create experimentally new kinds." These endeavors are, as we have seen, still in progress. The destructive action upon bacteria of the chemical rays of light was known before 1888. Madame Henri has now found that moderate exposure to such light, like moderate doses of chemical poisons, may modify some kinds of bacteria without destroying their life.

The production of such changes of form and function as we have been reviewing in the bacteria has been studied with more striking success in the yeasts and some of the molds which are also minute sexless organisms. It also forms a feature of very great theoretical and practical importance in the proper understanding of the numerous races of Trypanosomes, those ever-wriggling lash-bearing animalcules found in the blood of mammals, birds, reptiles, and fishes, and causing several serious diseases, such as nagana, sleeping sickness, and other horse and cattle plagues. The relationship of the bacteria to the green filamentous Schizophyta—known as oscillatoria, which live in fresh waters and on damp rocks and walls—is one of great interest, of which I will write hereafter.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, MAY 15th, 1915

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876)	per year	$5.00
Scientific American (established 1845)	"	3.00
American Homes and Gardens	"	3.00

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VOLUME LXXIX
NUMBER 2056

NEW YORK, MAY 22, 1915

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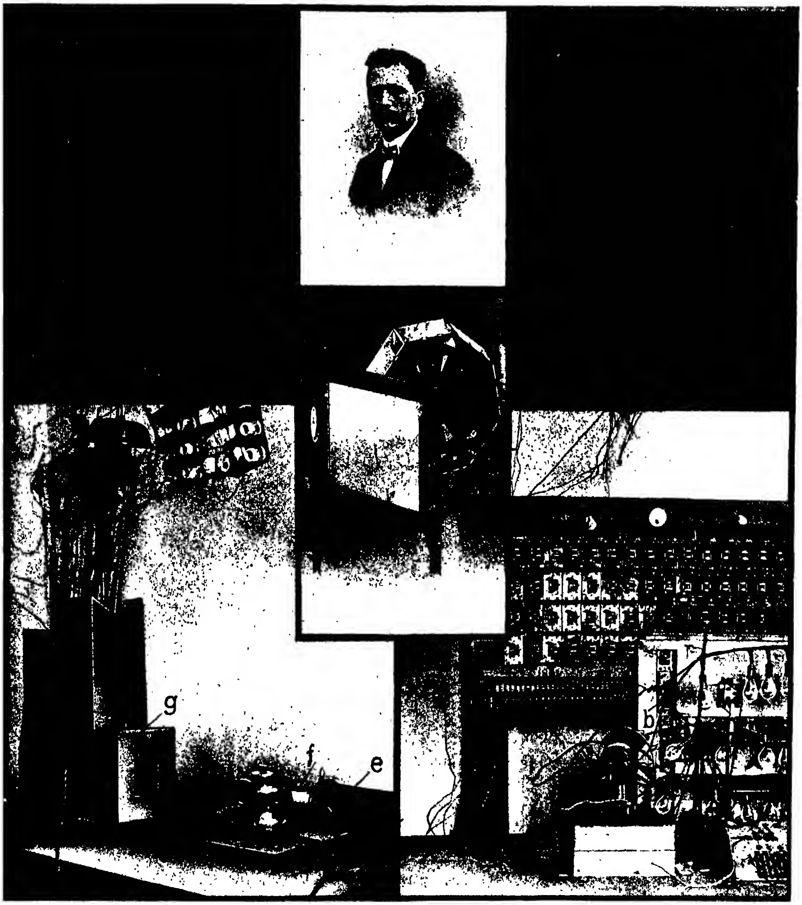


Upper Left-hand Illustration—The letter *E* in the Rignoux receiving mirror. Lower Left-hand Illustration—Receiving button: *e*, solenoid; *f*, nicol prism; *g*, arc light. Center Illustrations—Above, Georges Rignoux. Below, the receiving apparatus: *a*, translucent screen on which the images from the revolving mirror *d* are received. Upper Right-hand Illustration—The letter *L* in the Rignoux receiving mirror. Lower Right-hand Illustration—Transmitting station: *a*, magnetic relays; *b*, bank of 64 selenium cells.

The Telephotographic Apparatus of Rignoux and Reproductions Showing How the Letters of a Message Appear in the Receiver.—[See page 331.]

Various Forms of the Periscope*

Principles and Development of a Valuable Instrument Used in War

WHILE the periscope of the submarine is developing in the direction of greater optical perfection and elaboration, there has been a return to the simplest and earliest types of periscope for use in land warfare. Some of these trench periscopes recall the polemoscope, described by Hevelius in the seventeenth century for military purposes; this polemoscope in its simplest form consisted of two mirrors with their reflecting surfaces parallel to each other, and inclined at 45 degrees to the direction of the incident light. These mirrors were mounted in a tube and separated a convenient distance (Fig. 1).

For modern trench warfare the convenient separation is about 18 to 24 inches, and the mirrors are mounted

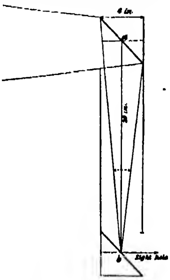


FIG. 1

in tubes, in boxes of square or oblong section, or attached to a long rod. In each case it is necessary that the mirrors should be fixed at the correct angle, and that there should be no doubling or distortion of the image.

The principal requirements of these trench periscopes are portability, lightness, small size and inconspicuous appearance, and large field of view. When there are no lenses the field of view is exactly the same as would be obtained by looking through a tube of the same length and diameter. Thus, with mirrors of 2 inches by 3 inches and a separation of about 22 inches, a field of view of 5 degrees would be obtained; and by moving the eye about, this field could be nearly doubled.

By using a box of oblong section the horizontal field of view can be increased without unduly increasing the size of the periscope. As the field of view is somewhat limited in any case, the principal objection to the use of a telescope or binocular, viz., the reduced field, no longer applies, and many periscopes are arranged to be used with a monocular or a binocular telescope.

Most periscopes can be used with a magnification of two or three, i. e., with one tube of an ordinary opera glass; but when higher magnification is to be used the mirrors must be of better quality, both as regard flatness of surfaces and parallelism of the glass. When the mirrors are large enough—8 to 10 centimeters wide—both telescopes of the binocular may be used, but in this case the requirements for the mirrors are even more stringent, as the images formed by the two telescopes will not coincide unless the mirrors are plane. When suitable lenses are placed between the mirrors, the size of the mirrors can be reduced or the field of view increased; it is easy to provide a small magnification of the image or even to arrange for a variable magnification.

In such cases the lenses must be arranged to give an erect image, or mirrors or prisms employed to erect the image. An example of a periscope of this type is shown in Fig. 2, where the mirrors are replaced by reflecting prisms, and the prisms erect the image in much the same way as the prisms of a prism binocular.

This arrangement is very suitable for a large magnification, but for larger fields the prism is unsuitable, unless it be silvered, and it is preferable to erect the image by means of lenses.

When longer tubes are used or larger fields are required, the design should approximate to that used in the submarine periscope.

This optical system has been steadily developed since its first introduction by Sir Howard Grubb in 1901.

The system consists of two periscopes, of which one is reversed, so that the image would be reduced in size, while the other magnifies this image, so that the final image is of the same size as the object, or is magnified one and a quarter or one and a half times. (As a very large angular field of view is required in these periscopes, the beam reflected into the tube must cover a large angle, and would soon fall on the sides of the tube; the reversed telescope, however, reduces the angle of the beam, and so enables it to proceed far enough down the tube to be received by the second telescope, and so transmitted to the eye.)

In modern submarines the tube has a length of from 16 to 24 feet, the diameter is from 6 to 9 inches, while the field of view is about 65 degrees. In order that objects shall look their real size, it is necessary to give a magnification of one and a quarter to one and a half.

Fig. 3 gives an illustration of a periscope in which three telescope systems are employed. The drawing is made from information published by Messrs. Goerz[1] of Berlin, and relates to periscopes made by them. It is, of course, undesirable to give any details of English periscopes at the present time.

An outer tube has a spherical glass cover. In the inner tube is the optical system, which can be rotated to face in any required direction; the eye piece, however, remains fixed.

The optical system, which follows in its general principles Sir Howard Grubb's original design, consists of:

(1) A reversed telescope, giving a reduction of about one quarter;

(2) A telescope, giving a magnification of about two;

(3) An erecting prism which can be rotated so that the image given by the system is correctly oriented;

(4) A telescope giving a magnification of about three. This telescope includes a fixed eye piece and prism, so arranged that the observer looks horizontally at the object. At the focus of the eye piece are placed a scale and pointer to show the bearing of the object sighted, and a ruling to allow the distance to be estimated when the size of the object is known.

By the aid of a subsidiary system, special parts of the field can be further magnified to allow of objects being examined in more detail.

The continued use of the periscope is very trying to the eye, so that devices have been used to throw the image on to a ground glass screen. The ordinary eye piece and ground glass systems are made interchangeable, so that the observer can readily pass from one to the other; he may observe with the ground glass in the ordinary way, but examine special objects with the ordinary eye piece.

The field of view of the periscope is still limited, and various attempts to overcome this difficulty have been made. More than one periscope can be used and the images combined to form a complete image. A recent improvement consists in the use of a ring reflector

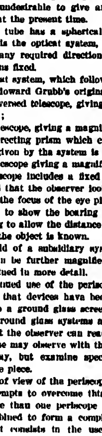


Fig. 2.

which enables a view of the whole horizon to be obtained at once. The image formed by the ring system is much distorted, but when any object is picked up it can be examined by means of the ordinary system. These two optical systems are combined in one instrument, so that the two images are seen in the one field, the image formed by the ring system surrounding the other.

But these ring periscopes are still far from perfect, their distortion making it very difficult to identify objects; and this difficulty, though not so pronounced, occurs with the ordinary periscope. The point of view from which the surface of the sea and surrounding objects are seen is one to which the eye is not generally accustomed. The conditions of lighting, too, render it difficult to distinguish objects, especially when there is mist or spray, so that the effective use of a periscope requires considerable skill and training.

Trench periscopes may be obtained from most opticians, and the following are a few typical forms:

The Hampson, wooden stake carrying two mirrors; price 7s. 6d.

The Adams, jointed rod; price 10s. 6d.

The Stanley; the support is in the form of lazy tongs, and is of a light alloy; price 25s.

These open-mirror types are light, portable, with good field, but the mirrors are not protected from rain, and the useful field is surrounded by bright sky.

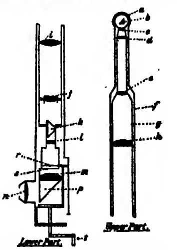


FIG. 3.—a, Glass cover; b, prism; c, d, and e, lenses of reversed telescope; f, outer tube; g, inner tube; h, i, and j, lenses of second telescope; k, reversing prism; l, m, and n, lenses of third telescope; p, prism; r and s, pointer and scale; t, rotating mechanism.

Tube types are made by Messrs. Negretti and Zambra, Dixey, The Periscope Company, and many others; prices from 8s. 6d. to 15s., depending on the metal tube used. In these types the field is rather limited.

Messrs. Charles Baker & Co. supply a type with large mirrors, which can be satisfactorily used with both barrels of a binocular. In spite of the large mirrors, the type is very portable; price 30s.

Many makers supply types in which the optical system is incorporated with the periscope, and the prices of these range from 28s. to 6l. 10s., according to the type of optical system used.

* S. D. Chalmers, in *Nature*.

[1] Dr. Weichert. Jahrbuch der Schiffbautechnischen Gesellschaft, 1914.

Battery-Operated Locomotive Headlights

IT is rather notable that the Southern Pacific road is using battery operated lights on its locomotives. The battery outfit is a 300 ampere-hour lead cell storage battery that is carried on top of the boiler, from which it is removed at the end of each trip for recharging by a special crane. The headlight takes 18 amperes at 6 volts, and the battery will operate this, together with three cab lights and two "blizzard" lights, for thirteen hours. For the headlight 140 candle-power nitrogen-filled tungsten lamps are used in the old standard reflectors.

Ozone Sterilizing Plant

A GOOD example of the Otto ozone sterilizing process by electric apparatus is seen in the plant at Sables-d'Olonne, France, one of the well-known Atlantic Coast watering places. The water is first put through sand filters in order to clarify it, and then goes to the ozone plant. A producer gas engine and dynamo furnishes the current for ozone apparatus and for motors. From the main well electric motor pumps take up the water and send it into the ozone sterilizing tank. The water then flows into a cistern from whence other electric pump groups deliver it to the town piping. The present plant contains apparatus for 6,000 cubic feet an hour total, and is laid out in two identical groups of 3,000 cubic feet each. A separate dynamo group is provided for each group, so that they are independent. Two electric pumps serve to supply the filter basins from the source, and another pair of pumps of 3,000 cubic feet output each handle the water between basins and sterilizer. For the offtake of the sterilized water there are also two centrifugal pumps of the same type, making six pump groups in all for the plant. We should say that since the installation of a similar plant at Nice the mortality fell from 40 per 1,000 inhabitants annually to 15 per 1,000, which is an excellent result.

The Romance of Motion Pictures*

A Scientific Toy that has Grown to be a Great Commercial Factor

By C. Francis Jenkins

WHERE the idea of motion pictures originated I do not know. But a hundred years before Christ, Lucretius strangely wrote his friend, thus:

"Do not thou moreover wonder that the images appear to move, and appear in one order and time their legs and arms to use; for one disappears and instead of it appears another arranged in another way, and thus seems each gesture to change. For you must understand that this takes place in the quickest time," which is an exact description of the motion picture of to-day.

If this is really what he meant, then it took two thousand years to get a suitable picture ribbon and a perfect machine to handle it, and ten years more to put the business on a paying basis. When we had motion pictures at the Atlanta Cotton States Exposition, in 1895, we were not able to convince the people there was anything inside worth looking at. So we threw the doors wide open, inviting the weary sightseers to come in and sit down for a rest, and after the exhibition explained that anyone who wished to contribute twenty-five cents for the exhibition he had seen of this wonderful new invention, might leave it at the box office going out, and we should be duly grateful therefor. Nor was our confidence in the American's love of fair play misplaced, for the money began to roll into the box office.

The year before, in Washington, I found it just as difficult to make personal friends understand in advance what these pictures were. And again, in the winter of 1894-1895, in an exhibition before the Franklin Institute of Philadelphia, a gentleman, in seconding a motion which had been proposed by someone that the society award the Elliott-Cresson Medal for this invention, said, that while he heartily seconded the motion, he would like to inquire whether Mr. Jenkins could tell them of any way by which the device could be made commercially profitable. I had to admit that I could not, for I was only an inventor, and an inventor rarely knows how to make money for himself.

And so matters drifted along some eight or ten years until a venturesome spirit opened a little five-cent theater in a vacant store on Fourteenth Street, near Broadway, in New York city. He made arrangements with cameramen which guaranteed him a new picture every day, and this was the beginning of the motion-picture theater industry and a film exchange system which has continued until now.

So now we have a device for dramatic representation which gives us every form of entertainment known to man since the beginning of time. We present the story teller in a pantomime far more effective than mere words alone; we show every form of spectacular reproduction in a splendor never dreamed of by a Cæsar; we present every human emotion known to exist in a realism and costume true to nature; we multiply the magic lantern a thousand-fold in every reel; we bring every distant country, every strange people, every quaint custom, every new and wonderful invention, every scientific discovery, all this we bring to the stay-at-homes, and the humble nickel pays the fiddler.

Of the early workers in motion pictures Prof. Muybridge obtained an analysis of motion that caused artists to change their accepted notions. His animal locomotion studies have become classics. But little later Prof. Marie used motion pictures in certain scientific work he was doing, in Paris. And still later Anchutz, exhibiting motion pictures at the World's Fair, Chicago, 1893, with a box into which one looked to see small pictures. However, these gentlemen all contented themselves with analysis of motion, mainly. Where they tried synthesis the resultant pictures were but small. It fell to my lot to take the one step which made these little pictures large and unlocked the flood gates of a business amounting last year to near $800,000,000.

Motion pictures not only show strange, truthful things, but will entertain you with unreal things with such a realistic semblance of truth that you grip your chair in excitement. You follow with the hero through all the stages of love and hate and passion, and settle down with a sigh of relief when the crisis is past. It may be you see the professor walking in the street, head bowed in abstract thought, knocked down by a ten-ton road-roller and rolled out as thin as a piece of paper, but picked up again goes on his way all unconcerned; or perhaps you see the mislaid mittens of a pickpocket crawl stealthily down from their shelf, cross the room, climb up the chair leg, up the man's back, reach quietly under his chin and steal the diamond from his tie? And you see these mittens caught in the act and locked in a solid box, go groping around inside searching every nook and corner for an avenue of escape, only to stop at the lock, and slowly unraveling, steal through the key-hole and deposit themselves in a pile of loose yarn on the table, and immediately thereafter patiently re-knit themselves into a pair of mittens again.

The moving picture is rapidly coming to be recognized by the educator as of great value in his work. The legislatures of three States have passed bills and appropriated money providing for motion pictures in their schools, while the law-making bodies of several other States are being urged to provide those pictures as an aid in instruction, it being conceded that picture education was our first and is the quickest and the most lasting. Education is simply the forming of mental pictures, but these pictures should be alike on every brain. If a class of a hundred students learn an oral lesson a hundred mental pictures are formed, but they are probably all different. If, however, the lesson is taught by motion pictures the hundred mental impressions are all alike. And these picture lessons are brought from every nook and corner of the earth, without translation, for the motion pictures speak a universal language.

Perhaps it is not known to all of you that this picture ribbon is the only unit that is standard in every country. Railway gages, for example, vary in different countries, units of value, volume, weight and of length differ, even the color of the people vary in every clime, but the motion-picture film is the same the world over. The usual unit length is 1,000 feet, known as a reel.

And now a word about the mechanism by which these results are attained. It may seem perhaps unnecessary at this late day to say that a motion picture is the synthesis of a long series of separate pictures placed end to end on a ribbon, and that these pictures are projected by means of a modified magic-lantern onto a canvas or screen, sixteen pictures per second. Each little picture is brought into the focus of the projecting lens intermittently, and it is this intermittent movement of the film at the picture aperture of the machine which is the vital feature of the mechanism. The device by which this is accomplished is an enlargement of the Geneva stop, found in many watches, to prevent winding the spring too tight.

Upon the accuracy of the locking portion of the driven member of the Geneva gears referred to depends the steadiness of the picture on the canvas, for the film must be started and stopped with microscopic exactness nearly one thousand times per minute.

The other of the two essentials of acceptable motion pictures to-day is the absence of scintillation or "flicker," as it is known in the art, which some years ago so affected one's eyes, often the cause of serious headaches. It is the alternation of the light and darkness caused by the passing shutter blade which causes the flicker, and this occurring sixteen times per second was painfully conspicuous. Later someone suggested cutting the light period twice more for each picture by putting on two more blades, resulting in forty-eight flickers per second instead of the original sixteen, and because the eye does not readily perceive forty-eight alternations of light and darkness per second flicker is practically eliminated.

The machine which I shall use to-night avoids the flicker, but in another way. It depends on the fact that it takes a perceptible time for the retina to recover sensitiveness after the impress of a strong light. So, if one impresses the picture on the eye for a sufficiently long time, relatively, one does not notice the changing of the picture, and little or no flicker is observable. This enables one to secure brilliantly lighted pictures with a small amount of current, for the picture is impressed on the eye continuously, except for the 1/160th of a second employed to bring each little picture into the projection aperture of the machine.

These two devices, then—the Geneva gear and a proper shutter—are the obscure essentials of the modern picture-projecting machine for producing a steady, flickerless picture, while all the others elements are simply matters of convenience or of fire insurance underwriters' requirements.

Two changes are rapidly nearing adoption to overcome conditions which have heretofore handicapped the owner of a photo-play house. First, within a very short time he will be able to choose a programme according to his own conception of the tastes and wishes of his patrons; and second, the price of admission will be higher and tickets will be sold which represent a particular seat in the house just as they are now sold for the ordinary talking theater.

This change of method logically results, and to show the reason for this trend in the art one might take, as an example, any one of a dozen picture-producing companies with studios located in southern California, where photographic light is practically uniform the year round. Here are hundreds of thousands of acres under purchase or lease, and above a million dollars' worth of wild animals, in great variety, handled by skilled animal trainers, the whole used as playground and accessories for the making of motion pictures which will entertain and instruct. At least $15,000,000 are invested in southern California in the making of pictures. These and other playgrounds are being used to produce pictures of a higher class and quality. The cost of each such picture runs into large figures, consequently film-rentals are higher, and a five-cent admission is no longer as profitable as formerly.

Some five or six years ago I happened to be in a studio in New York when a little girl and her friends came in from the street to watch the making of a motion picture and perhaps with the hope that they might be requisitioned for extras in the play. The play being photographed portrayed an old musician who had been unsuccessful in his efforts to have a piece of music he had written produced and had at last been reduced to the necessity of playing the violin on the street corners for such pennies as might be tossed him. Between times he had taught the little grandson to play the violin. And so the plot was laid. A boy was needed for the part. The director, glancing at the row of children against the wall, instantly picked out the particular little girl I have mentioned. Calling her to him, he asked: "Will your mother let your hair be cut?" The little girl thought so, but would go and ask, and away she ran, presently returning with the required permission; and so to the barbers they sent the lassie, while a messenger was dispatched to buy a boy's suit. I distinctly remember seeing the director tearing the pockets and slashing the coat with his knife to make a new suit look like an old one. In the opening scene the lad "rustles" the few dishes and pans in supper anticipation until presently the old man comes in and drops wearily into a chair. The little fellow runs to him and strokes his forehead and hair until he falls asleep under the gentle touch. Then he slips quietly out of the room with the violin and bow under his arm. In the next scene he bursts into the room with his hat full of money, and waking the old man shows him their wonderful luck. That little girl was Mary Pickford. She received $5 for her day's work; but what was more important, it was seen that she possessed in exceptional degree those rare characteristics so necessary in the picture business—a good photographic face, the gift of feeling the part played, and the ability to do it in pantomime. Her salary to-day is $2,000 a week whether she works or not, and she is known to every motion-picture "fan" in the whole world. Of course, not all players get any such salaries, but it is this very example of erstwhile unknown people reaching up to big pay envelopes that has caused the almost wholesale exodus of mount into the billions; and surely a business which theaters, from the "divine Sarah" to the most lowly player. But I assure you that many of them will be disappointed, for acting before a camera is a very different thing from acting before the footlights. The best players for motion pictures are those who have grown up with the business. They don't have to unlearn anything.

Among the producers the same story might be told. I can name among my own personal acquaintances at least a dozen millionaires who four to eight years ago had practically nothing. But do not for a moment think that money is so easily made in motion pictures that it requires no effort of judgment, for while an opportunity is there, it takes judgment in this business just as surely as it takes judgment in any other business.

So this is the industry which has grown up since the little exhibition which I gave in 1893 in the first club rooms of the Capital Camera Club, an industry which has grown until the property interests represented mount into the billions, and surely a business which gives so much pleasure to more than ten million of people daily cannot be wholly had.

*Address delivered before the University Club, Washington, D. C., [illegible].

The Measurement of Distances in War*

Ingenious Modern Methods and Instruments Now Used

In war the direct measurement of the distance of the enemy's position is out of the question, and measurement by triangulation is practicable only in fortified places. In all other cases, until recently, distances could only be guessed. Many attempts have been made to devise accurate methods of measurement, but all of the older methods are too imperfect or too laborious for practical use.

Fig. 11.—The stereoscopic telemeter in use.

In 1899 Pulfrich invented for the Zeiss Company a remarkably accurate and convenient instrument which has since rendered very valuable service.

The Zeiss stereoscopic telemeter is based on the principle of stereoscopic or binocular vision. A good eye can distinguish objects seen under a visual angle of 30 seconds, which is equal to the angle between the apparent directions in which an object about 1,500 feet away is seen by the right and left eyes. The stereoscopic effect, therefore, is appreciable at this distance, which may be called the depth of the stereoscopic field. This depth may be increased either by using a binocular field glass or by artificially increasing the effective interocular distance. The second method is adopted in the telestereoscope of Helmholtz, which consists essentially of two pairs of inclined mirrors, arranged in the manner indicated by Fig. 1. The large lateral mirrors *SS* are parallel respectively to the two small central mirrors *JSp*, which are rigidly connected at right angles to each other. (They may be adjacent faces of a right angle prism.) Each eye sees the landscape by double reflection from the large and small mirror on one side, and the effect is the same as if the eyes were moved outward to the positions of the lateral mirrors *SS*. If the distance between these mirrors is six times as great as the real interocular distance (2.6 inches), the effective interocular distance and the stereoscopic effect are increased six-fold and, as all dimensions are estimated in relation to the interocular distance, the landscape appears six times smaller and six times nearer than it is in reality. The same effect can be produced by viewing the scene directly with the left eye, and holding before the right eye a small mirror, inclined 45 degrees to the line of sight, which reflects into the eye the image of the scene formed by a larger parallel mirror placed 15 inches to the right.

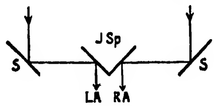


Fig. 1.—Helmholtz telestereoscope.

LA, left eye; *RA*, right eye; *JSp*, inner mirrors; *SS*, outer mirrors.

If a binocular field glass is interposed between the telestereoscope and the eyes, the scene is again apparently brought nearer, but without reduction of scale, to a degree proportional to the power of the field glass. This combination of field glasses with the telestereoscope is realized in the Zeiss relief telescope (Fig. 2). The visual rays are reflected by prisms at each end of the telescopes, in the manner indicated in Fig. 3. If the magnifying power of the telescopes is 12 and their outer ends are separated by 10 times the real interocular distance, the stereoscopic effect is $12 \times 10 = 120$ times greater than it is with the naked eyes. The depth of the stereoscopic field, therefore, becomes $120 \times 1{,}500 = 180{,}000$ feet, or 34 miles. The depth can be increased to more than 100 miles by employing longer and more powerful telescopes.

The telescopes are hinged at their inner ends and the stereoscopic effect can be diminished by bringing them together (Fig. 4). When they are folded as closely as possible the stereoscopic effect is least, but in this position they are very useful in many cases, for the observer can keep his head under cover, allowing only the ends of the tubes to protrude.

A similar, though smaller, stereoscopic effect is produced by the Abbe-Zeiss prismatic field glass (Fig. 5), in which the objectives are about twice as far apart as the eyes, so that, with a magnifying power of 10, the depth of the stereoscopic field is $10 \times 2 \times 1{,}500 = 30{,}000$ feet, or nearly six miles.

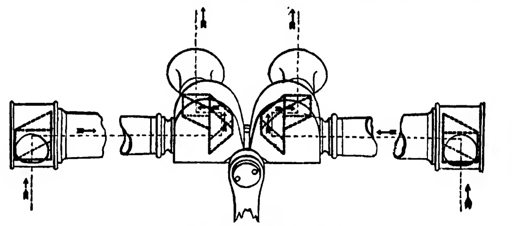


Fig. 3.—Path of rays in Zeiss relief telescope.

In both of these instruments two slightly different images of the scene are produced in the focal plane of the objectives and are viewed through the eye-pieces. The stereoscopic impression of distance is due to the fact that the two images of a near point are less widely separated than the images of a distant point. If two marks, m_1 and m_2, are placed in the axes of the eye-pieces, just in front of the focal plane (Fig. 6), they will appear as a single mark at infinite distance. If the mark m_2 is then moved to the position m', or m'', it will combine with m_1 to produce the appearance of a mark at the distant point m' or the nearer point m''.

In this manner the mark can be brought into apparent coincidence with a church steeple or other object *P*. The distance of this object can be calculated from the amount by which the movable mark has been displaced from its zero position m_2.

Instruments with movable marks have been constructed and employed in practice, but they require a separate calculation for each observation. It is far more convenient to place in the focal plane a fixed scale, so graduated that each interval corresponds to a distance of 100 meters. This produces in the field of the telescope a scale of measurement that can be applied to any part of the landscape. The operation of this device is illustrated in Fig. 7. The marks m'_1 and m'_2 engraved on the glass scale, produce the appearance of a single mark m', at a distance of 500 meters, for example. Two other scale marks produce the stereoscopic image m'', at a distance of 600 meters, and so on. Hence, a church steeple *P* that appears midway between m'' and m''' is 650 meters away. Usually the scale is made in three inclined sections and the rows of marks appear to traverse the scene in zigzag receding lines, as will appear in the most striking manner if Fig. 8 is viewed through a stereoscope, or if each side is viewed with the corresponding eye, a large card being held vertically between the eyes, if necessary.

Fig. 8.—A view through the stereoscopic telemeter.

The Zeiss stereoscopic telemeter, in which this measuring device is employed, is shown in Fig. 9, and the path of the visual rays in the instrument in indicated in Fig. 10, while Fig. 11 illustrates the method of using the telemeter without the aid of a stand.

The instrument is made in three models, having the following dimensions:

Model.	Length.	Magnify'g Power.	Stereoscopic Depth.	Range.
I	51 cm.	8	28 km.	75 to 3,000 m.
II	87 cm.	14	84 km.	200 to 5,000 m.
III	144 cm.	23	228 km.	700 to 10,000 m.

For the same distance, more accurate results are obtained with large than with small models. The tube is too stiff to bend appreciably and an envelope of felt protects it from unequal heating, which might produce curvature. The eye-pieces can be adjusted to the in-

* Abstract of Prof. Keller's article in *Die Umschau*. Translated for the SCIENTIFIC AMERICAN SUPPLEMENT.

Fig. 2.—Zeiss relief telescope.

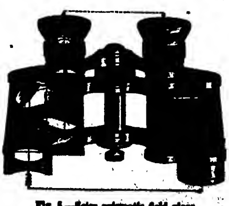


Fig. 5.—Zeiss prismatic field glass.

terocular distance of the observer, and the scale can be illuminated for use at night. The heights of objects can be inferred from the marks already described, which rise and diminish in size as they recede, but the instrument also contains a vertical scale for more precise measurement of heights.

The stereoscopic telemeter is especially valuable for

Fig. 4.—Zeiss relief telescope folded.

measuring the distance of a moving object and in disturbed conditions of the atmosphere, when it is impossible to use a theodolite, and it is indispensable for measuring the elevation of airships and aeroplanes. The instrument, furthermore, gives a simultaneous comprehensive view of the distances of all points in sight,

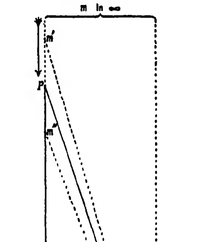


Fig. 8.—Principle of movable marks.
L, left eye; R, right eye.

while the theodolite requires repeated settings and tedious calculations in order to deduce the distance of a single point. The stereoscopic telemeter, in short, puts the observer in possession of an exact, living model of the field of action and also of a convenient scale for measuring all distances in every direction, even the caliber of the mouths of the enemy's cannon.

Fuel Oil*

The use of oil in one form or another as fuel for generating power or for domestic heating should be considered under several conditions: First, where oil is the most efficient source of heat and power because of the absence or inadequate supply of cheaper fuel. This is the condition on the entire Pacific slope. Second, where the use of oil as fuel represents a means of disposing of excess accumulation of crude oil, residues, or distillates, for which no market is at hand. This condition frequently prevails in the newer fields of the United States; it always represents a means of disposal by the refineries of undesirable products which would otherwise go to waste. There is a third condition of use of crude oil or its products as fuel which is in a radically different class. This is its application to the generation of power by making steam or in internal combustion engines in the Navy and the merchant marine. This use is not so strictly limited by the price.

The production of a sudden flood of new oil in any part of the world naturally carries with it the utilization of more or less of this oil for fuel when the price per barrel goes below the limit of competition with coal. Thus at present in Wyoming, although that State contains adequate supplies of coal, use is made of the otherwise unsalable products from the Casper refineries for locomotive service over long distances in that State. This use must naturally increase from the fact that the production of oil in Wyoming is extending faster than any possible adequate market for the heavier products.

Crude oil seldom remains cheap for a very long period, and therefore the supply for railroad use and for other fuel purposes is so unreliable that crude oil as a fuel has lost favor very rapidly, and recourse is eventually made to those products from the crude, which happen in the particular oil under consideration to more than supply the demand for those particular products.

A short time ago the separation of a given crude oil into marketable products was strictly limited by the quantity of those different products naturally occurring in the crude oil. But more advance methods of refining have lately included the ability to break up the less salable products in crude oil, and thus increase to a very great extent the yields of those products which are most salable.

An interesting example of this is found in California, where the oils obtained a few years ago contained only small percentages of gasoline and kerosene, so that there was a very large quantity of heavier products from the oil, all of which happened to find a good market as fuel. At first, in order to make up the deficit in gasoline and kerosene, gasoline and light crude oils containing much gasoline were imported from Borneo and Sumatra; then recourse was made to extracting gasoline from such natural gas as occurs in association with oil and contains considerable quantities of gasoline vapor. Within the last two years, following this extraction of gasoline from natural gas, the supply of gasoline has also been augmented by cracking the heavy crude oils under pressure, with the resulting production of "motor spirit."

Within the last two years also, a more significant change has occurred. The oils recently produced, especially those from considerable depth, have shown a much greater content of gasoline and kerosene—so much so, indeed, that the effort to produce an adequate supply of gasoline has been overdone. This material, so much in demand in the Eastern United States for automobile and other internal combustion engines, has glutted the market of the Pacific coast, with consequently greatly decreased prices.

It is evident that the ability of the refineries to furnish, from all kinds of crude oils, those products which are in greatest demand has enormously increased within the last few years. As a result there is much less of any waste product to be thrown into the waste tanks and sacrificed under the general term of fuel oil. The prices of this material rose significantly in all parts of the eastern fields. Low prices for fuel oil in the future will depend chiefly upon the production of oil of all grades, in such quantity that much of it can only find market as fuel.

Within the last few months, however, the tendency toward cheaper fuel oil has increased because of the producing of low-grade crude oils in larger quantity in the Gulf field of Louisiana and Texas—that is, at Vinton and Edgerly in Louisiana, in Orange County in Texas, and also at greater depth in the old fields of Sour Lake, Saratoga, and Batson, in Texas.

The mid-Continent fields are forcing the heavier oils of the Gulf region to find a market elsewhere, chiefly as fuel. These Gulf oils yield good lubricants, but only a small proportion of the supply can find a market for that limited use. Further, the large fleet of tank steamers lately built enables Mexican oils to invade the eastern coast of the United States. This makes it probable that a large use of fuel oil may become a feature in manufacturing enterprises of the east coast region, and that while this use is being developed careful study will be given to modern methods of burning oils in internal combustion engines. It should be borne in mind, however, that if this substitution of coal by oil receives very great favor the movement would easily

Fig. 9.—The Zeiss stereoscopic telemeter.

overtax the limitations of all the tank steamers in the trade. In the meantime, the advantages of fuel oil for marine engines are so great that the navies of the world will demand it independent of its price, and the merchant marine will be obliged to give this matter extremely careful consideration. Should an outlet for fuel oils really be opened by one large transatlantic steamship line, the effect upon the price of fuel oil would be marked.

* From the report of the United States Geological Survey on the Production of Petroleum in 1913.

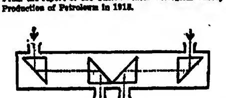


Fig. 10.—Path of rays in Zeiss stereoscopic telemeter.

Harvest Forecasts for 1915

The Board of Agriculture and Fisheries have received the following information from the International Agricultural Institute:

Reports have been received on the sowing and the condition of winter cereal crops in the Northern Hemisphere.

Regarding the extent of crops, there is an increase in the area sown in comparison with the 1914 area of wheat in Italy (12,350,000 acres, an increase of 5 per cent), in Canada (1,293,000 acres, an increase of 38

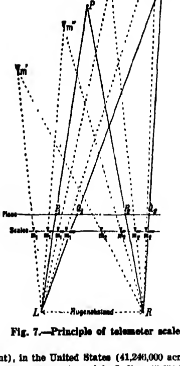


Fig. 7.—Principle of telemeter scale.

per cent), in the United States (41,240,000 acres, an increase of 11 per cent), and in India (28,681,000 acres, an increase of 22 per cent). For the present crop conditions are not generally stated to be abnormal.

For wheat the 1914-15 harvest forecasts are available for Argentina, Chile, and Australia, the total present crop in all these countries being estimated at 131,748,000 hundredweights, compared with 123,054,000 hundredweights in 1913-14. The excellent yields of Argentine and Chile largely compensate for the reduced crop in Australia.—*The London Daily Telegraph.*

Atoms and Ions—IV*

A Comprehensive Discussion Especially as Related to Gases

By Sir J. J. Thomson, O.M., F.R.S.

Continued from Scientific American Supplement No. 2054, Page 311, May 15, 1915

In opening the fourth of his lectures, the lecturer said that he wished to draw attention to cases of ionization produced by heating various salts. The problems here involved had two aspects, according as the electricity was liberated from the solid salt itself or from the vapor occupying the space immediately above it. It was necessary that these two aspects should be kept apart and considered separately if clear ideas as to the nature of the ionization were to be attained. When certain salts were heated there was, he proceeded, a marked production of electricity, the character of which was found to depend a great deal on the nature of the salt. Where the electricity was liberated from the solid salt there was in some cases a marked excess of positive electricity, while with other salts it was the negative electricity which was in excess.

Taking a little aluminium phosphate and raising its temperature by means of an electric heater, the lecturer showed that when a plate connected to an electroscope was brought over the hot salt, the electroscope was rapidly discharged when its own charge was negative, but that the leakage was insignificant when the electroscope was positively charged. When aluminium phosphate was heated, he proceeded, positive electricity was produced in great excess, while with other salts similarly treated it was the negative electricity that was in excess. Whether the one result or the other was attained depended upon the chemical nature of the salt, and he had found an interesting connection between the character of the charge liberated by heating and that liberated when the salt was crushed in an agate mortar. Most salts, he said, got electrified when carefully powdered, and the sign of this electrification was the same as that of the electrification produced when the salt was raised to a high temperature. It would seem, therefore, as if in both cases the electricity was due to the tearing off from the salt of a surface layer of electricity spread over it. If this layer was removed to some extent by powdering or by heating, we should get exactly the effects observed.

It was important in such cases to know what was the carrier of the electricity produced. The usual method of measuring the mass of the carriers was not readily applicable in experiments of this kind, as the high temperature would affect the photographic plate or phosphorescent screen used. Another plan was therefore adopted. A plate connected to an electroscope was placed parallel to the plate supporting the heated salt, and between the two plates and parallel to them a strong magnetic field was established. If the field were destroyed, every electrified particle from the salt would reach the opposing plate and help to discharge an electroscope connected therewith. On re-establishing the field, however, the magnetic force would curl round the paths of these particles into circles, and the stronger the field the sharper would be the curvature of the trajectories. Hence by making the field sufficiently strong, the orbits of the particles would be bent round so much that none of them reached the opposing plate, but fell back on to the salt below. Hence by varying the magnetic field, it was possible to pass from a state in which all the particles reached the opposing plate to one in which none of them did; and the transition was a pretty sharp one. Knowing the distance at which the particles just failed to reach the plate, the ratio $\frac{e}{m}$ could be determined by means of the equation:

$$d = \frac{2X}{H^2} \cdot \frac{e}{m}$$

where d denoted the distance between the plates, X the electric force urging the particles from one plate to the other, and H denoted the magnetic field.

From experiments based on this principle, it had been found that when either sodium or potassium was contained in the salt heated, the carriers of positive electricity were nearly always atoms of one or other of these metals. Indeed, Prof. Richardson had gone so far as to maintain that atoms of alkaline metals were the carriers in all cases, whether the salts were or were not supposed to contain sodium, the alkali being present, in fact, as an impurity.

The speaker had himself made experiments on the nature of the carriers produced when platinum was heated, and found for them, in this case, an atomic weight of 28, which fitted in very well with the supposition that the carriers were molecules of carbon monoxide. He believed that in the majority of cases it was the gases absorbed on the surface of the bodies under investigation which provided the carriers, and CO was always given off when metals were heated in vacuum, and his own experiments supported the view that in such cases the carriers were molecules of this gas. If the carriers were sodium atoms, the atomic weight found should have been 23 instead of the 28 actually observed. Nevertheless, in cases in which the salts under investigation actually did contain sodium, Richardson had got very abundant electrification, showing that sodium and potassium were very well adapted to serve as carriers of positive electricity, but the lecturer could not accept the view that the carriers were in all cases atoms of these metals.

He would next consider cases in which the electrification arose from the vapor of the salt, and could be detected even if this vapor were sucked off into another vessel, and tested there. This phenomenon had been specially studied by Schmidt and Kalandyk, the latter working in the Cavendish laboratory. The vapors examined were those of cadmium iodide, zinc iodide, and zinc bromide; these vapors showed a high conductivity, and there must therefore have been a separation of the positive and negative charges in the molecule. By determining the way in which this conductivity varied with the temperature, it was possible to calculate the work required to separate the charges, and in this way Kalandyk had found for cadmium iodide the value 1.79 volts, which, it would be seen, was very much less than the 5 volts required to ionise mercury vapor. This was an interesting instance of ionization being effected with a very small expenditure of energy, and apparently the ionization of the vapor of this salt might be considered to be a genuine ionization of a gas, effected with an energy expenditure of less than 5 volts. There was, however, one suspicious point in the matter—viz., that the ionization was greatly increased if a little water vapor were present. There were other cases in which the presence of water vapor had a marked effect on the production of electricity. Thus, if sulphate of quinine were heated to about 180 deg., and allowed to cool, it gave out electricity, if the cooling took place in such conditions that water vapor could be absorbed, but none if water vapor were excluded from the cooling salt. In all these phenomena we found throughout the enormous influence exerted by the presence of difference substances. When the greatest precautions were taken to purify the bodies under investigation it was found that in many cases the effect diminished to a mere fraction of its original value. For example, the purer aluminium phosphate was the less was the electricity produced on heating it. Again, Pring and Parker had found that by taking extraordinary care to get rid of the gases occluded by carbon, the ionization produced by heat was diminished to less than one millionth of its original value.

All through these observations the importance of mixtures was, in fact, very evident, and in all these cases we were perhaps in the presence of the oldest type of ionization known—viz., the electrification produced by friction of dissimilar bodies. This was the original method of producing electricity, and as yet but little definite was known about it.

The hypothesis which for the present fitted in best with the facts observed was that when two different molecules came sufficiently close to each other, there was a tendency for negative electricity to pass from one to the other. In general, however, sufficient energy was not available to separate the positive and negative charges from each other to any appreciable extent; but the bond between the two had, as it were, been cracked, and the operation could then be completed by brute force, applied either mechanically or by heat treatment. Volta was not able to show the electricity produced by contact of copper and zinc, but on pulling them apart again—an operation requiring the expenditure of work—the effect produced was large enough to affect even his comparatively insensitive instruments. On this view, the putting of two different molecules together served as a delicate tool capable of starting the joint between the charges, putting them into a state in which the separation could be completed by "unskilled labor" in the shape of friction or heat. This viewpoint made obvious the great effect on electrification to be expected from the presence of impurities in the bodies under examination. Thus the hydrogen occluded in charcoal coming into contact with the molecules of carbon produced a difference of electrical condition, and then a supply of heat furnished the energy necessary to separate the positive and negative charges to an appreciable extent.

Having considered so far what different agents produced ionization, the lecturer said he would next discuss a case in which electrification was observed, but of which the origin was most obscure. Ordinarily air was regarded as devoid of conductivity, being a typical insulator. Nevertheless, very delicate experiments had shown that ordinary air did possess a certain amount of electricity, though not very much. To demonstrate this the lecturer sucked a large quantity of air through a tube, along the center of which was a wire connected to an electroscope, the wall being earthed. On setting the pump to work, the electroscope showed a very slight but continuous loss of charge, which stopped on stopping the pump. The conductivity which caused this loss of charge was, the lecturer said, in part due to the presence of radium or its emanation, which, in fact, was responsible for about half the conductivity found in the air of an ordinary room. If, however, the conductivity was measured of the air inside a box with very thick walls of lead, thus screening out any action of radium, some conductivity was still to be observed. Similarly, if the state of the air was measured in mid-ocean, near the center of a frozen lake, or in other places where the effects of radium were excluded, this residual conductivity was always perceptible. Measurements made nearly all over the world showed, moreover, that this residual conductivity was much the same everywhere, from Canada to near the South Pole. In amount it corresponded to the production of four ions per second per cubic centimeter of air. This might seem so small as to be ridiculous, and, in fact, the year's birth-rate of ions against the molecules of air was less than one in a million, but this residual conductivity was, nevertheless, one of the most interesting problems now under consideration.

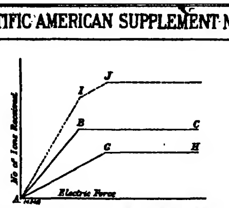
These four ions per cubic centimeter per second were produced whatever the region of the globe in which the experiment was made, and whatever the material of which the box was constructed, and this occurred with the walls so thick that no radiation of which we had as yet any experience could penetrate from the outside. How these ions were produced was the problem. It might be thought that they were caused by molecular collisions, since by the kinetic theory of gases particular particles might possess an abnormal energy, sufficient, perhaps, to liberate electricity on colliding. On this hypothesis, however, the rate of ionization should increase very rapidly with a rise of temperature, but apparently temperature changes had no appreciable effect. Throughout a range extending from 0 deg. Cent. to 180 deg. Cent. the number of ions produced was practically constant, whereas did they originate in a bombardment by exceptionally quick molecules, the rate of ionization should have been far more at 180 deg. Cent. than at 0 deg. Cent.

What the explanation might be was a matter of absorbing interest. The conductivity could not be due to a special radiation from the walls of the vessel, as the ions were produced at the same rate per cubic centimeter whatever the size of the vessel, although in small vessels the ratio of wall area to cubic content was greater than it was in large vessels. At present, indeed, the whole matter was a mystery. Perhaps the gas itself gave out something like Röntgen radiation, which was not affected by temperature changes, or possibly it might be due to some other gas or compound mixed with the air in very small quantities, which could be ionised at ordinary temperatures. At present, however, we had no light on the source of these four ions per cubic centimeter per second, which were generated in ordinary air, after all external influences were screened out. It would, the lecturer said, be very interesting to try how this residual conductivity varied with the nature of the gas, but so far as he knew no experiments had yet been made on this head.

In town air, or in other places where there was much dust, the ions produced were mostly absorbed by the dust, and the electricity was borne by these dust particles, and not by the molecules. Experimenting at Paris, Langevin had found that there were [illegible] times as many ions caught by the dust [illegible]

* Reproduced from Engineering

molecules of air; while in the open country, where there were comparatively few dust particles, the electricity was much more mobile, being carried by molecules. A peculiarity found by Langevin was that there were no ions intermediate in size between molecules and great, heavy things like dust particles. Under a field of 1 volt per centimeter "molecular" ions would move at the rate of 1 centimeter per second, while the "dust" ions in the same field would only move at the rate of 1/1,000 millimeter per second. Langevin had used a very ingenious method of determining the type of particle present. Passing a stream of air through a tube across which an electric field was established, the particles were impelled toward the wall. With a certain strength of field all the particles of a particular size within a given distance from the wall would be drawn down and captured before they escaped from the tube. By increasing the field, the thickness of the layer from which the



whole of the ions were removed would be increased, and, finally, a certain stage would be reached at which all the ions of that kind contained in the flowing stream would be removed. Up to this stage, assuming one kind of ion only to be present, the number captured would be proportional to the electric force, so that a graph between this force and the number of ions captured would have the form indicated in the annexed diagram by the ABC. At the point B the whole of the ions would have been taken out, and no further increase in the electric force would raise the number captured. There would thus be a sharp kink at the point B. If the ions had been of a more slowly moving kind, a flatter curve, such as represented by AGH, would be obtained, the kink at G denoting the point at which all these heavier ions had been captured. If, however, both kinds of ions were present in the air, the combined curve, having the two kinks IJ, would be obtained. Each kink, in fact, denoted the existence of a different kind of ion, and Langevin's curve contained two kinds only, showing that only two types of ions were present, one being gaseous molecules, the other particles of dust.

(To be continued.)

How Much Albumen is Needed in Our Diet?*

Interesting Results of Some Extended Experiments

Prof. Max Rubner asserts that the quantity of albumen required to keep the human organism in balance varies with the character of the diet, because the albumens of foods differ in nutritive value, so greatly that a man requires 81 grammes of the albumen of bread for his daily needs, which are satisfied by 25 grammes of the albumen of meat. This statement is based on experiments in which men were fed on bread alone for three days. The minimum daily loss of nitrogen in the urine was 13 grammes, the quantity contained in 81 grammes of albumen. Hence Rubner concludes that 81 grammes of albumen must be assimilated daily; 81 grammes of digestible albumen correspond to 90 or 100 grammes of total albumen. The minimum ration, however, should be somewhat exceeded in a standard diet, and so Rubner approves Voit's old daily allowance of 118 grammes of albumen.

The statement that 81 grammes of albumen daily are required in a diet of bread alone has become a cornerstone of dietetic doctrine. As my earlier experiments with this diet had shown that the daily elimination of nitrogen could fall much below 13 grammes, I decided to investigate the question thoroughly. For this purpose two strong young men, 27 and 22 years old, were fed almost exclusively on bread, or on bread and fruit, for six months, from January to July, 1913. The experiment was divided into periods of about twelve days each. It began with three periods of a pure bread diet. In the first period the mean daily excretion of nitrogen was 9.0 grammes, the amount decreasing from 11.8 grammes on the first day to 8.8 grammes on the twelfth day. The mean daily intake of nitrogen in the food was only 9.6 grammes, so there was a mean daily loss of 0.8 gramme. In the second period the mean daily excretion was 7.6 grammes and the intake 8.1 grammes, showing a gain of 0.5 gramme. In the third period the excretion was 7.3 grammes, the intake 7.4 grammes, the gain 0.1 gramme; 7.4 grammes of nitrogen correspond to 46 grammes of digestible albumen, a quantity very much smaller than Rubner's 81 grammes.

In a research of this character a three days' test is utterly worthless, because it takes the organism from six to twelve days to come into equilibrium with a new albumen ration.

The equilibrium was maintained, even when the albumen in the pure bread diet had been reduced to 40 grammes daily. I could not reduce it further, although I used rye very poor in albumen, coarsely ground and unbolted, so that about 40 per cent of its albumen was lost in the feces. The experiments, however, proved the practically important fact that a pure bread diet sufficient for general nutrition supplies enough albumen to cover the daily outgo.

Theoretically, it would be interesting to investigate the possibility of maintaining equilibrium with a still smaller quantity of albumen. In some old experiments of this sort the subjects were fed on bread made of starch, but the bread was so poor that no subject could eat it for a long period. In other experiments sugar, starch and fat, prepared in various ways, were used, but this diet produced nausea, heartburn, gastric pains, and diarrhea. Nobody appears to have thought of the simple expedient of adding fruit to a bread diet. Strawberries, prunes, and other fruits contain little albumen and almost no digestible albumen, and they can be eaten in large quantities. A very palatable dish can be made of prunes, starch, and sugar. I found that a diet of this sort never caused digestive troubles. A typical daily ration comprised about 17½ ounces (500 grammes) of whole rye bread, 20 ounces of prunes, and 2½ ounces each of sugar, starch, and margarine. This ration contained 8.4 grammes of nitrogen, of which only 3.5 grammes were assimilated, the remainder being excreted by the bowels. But still the body gained nitrogen slightly, for only 3.4 grammes appeared in the urine; 3.5 grammes of nitrogen correspond to 22 grammes of albumen. This is little more than one quarter of Rubner's minimum (81 grammes) and is even less than his minimum allowance of meat albumen (25 grammes). Similar results were obtained in several experimental periods. The albumen of bread, therefore, is equal to the albumen of meat in nutritive value.

In earlier experiments, in which two subjects lived for a whole year entirely on potatoes and margarine, I found the minimum daily ration of albumen to be 20 to 25 grammes. This result also indicates that vegetable albumen is equal to animal albumen in nutritive value.

It may be asked whether my subjects remained healthy and vigorous on these diets. Rubner asserts that deprivation of albumen produces sluggishness, weakness, and unwillingness to work. If 81 grammes of albumen daily are required to maintain muscular strength, my subjects had good reason for weakness. In 162 days one of them received only 5,267 grammes of digestible albumen, instead of the 13,122 grammes corresponding to the daily minimum of 81 grammes. He should, therefore, have lost 8 kilogrammes of albumen, corresponding to 40 kilogrammes, or 88 pounds, of muscle.

This is more muscle than he possessed at the start and, as loss of any considerable proportion of the muscular weight is fatal, he should, theoretically, have died several times in the course of the experiment. This man, Frederik Madsen, has now lived for twelve years on a vegetable diet exceedingly poor in albumen. During the last eight years he has scarcely tasted milk or eggs, which many vegetarians consume in large quantities, and has very seldom eaten beans or peas. For a whole year he lived on margarine and potatoes, which usually contained only half of the normal percentage of albumen. In the following year he submitted to the six months' test described above. On Sundays and holidays, when he is not employed in my laboratory in Copenhagen, he works as a gardener, partly in order to earn money, partly for the sake of exercise. His capacity for work is so remarkable and so well known that he easily finds employment at high wages. During the spring of 1913, in the course of the six months' test, he worked in this way at a villa several miles from the city, going and returning on his bicycle, and working from one hour after sunrise until darkness compelled him to stop, without tasting food. (As a rule he never eats during working hours, except at my request, and he has never been induced to drink anything but water.) His employer testifies that work seemed play to him, and that he accomplished an astonishing amount of it, with never-failing cheerfulness and good humor.

In order to test the powers of the other and younger subject I allowed him, after the experiments were finished, to take part in a "Marathon" race of 262 miles, although, as he was entirely untrained, I did not expect him to complete the course within the time limit of 102 hours. He did so, however, in 99 hours.

A diet poor in albumen appears to increase endurance. I have never heard of a great meat eater winning a long-distance race.

It cannot be denied that meat "tastes good" to most persons, or that it stimulates metabolism, accelerates oxidation, and thus produces a temporary feeling of warmth and comfort. But the organs seem unable to endure this stimulation for long periods. The mortality from diseases of the liver, kidneys, and bowels is three or four times greater among well-to-do city dwellers than among peasants living chiefly on bread, potatoes, and fat. The Eskimos, who eat large quantities of meat, seldom attain the age of 60 years, and the mortality between the ages of 50 and 55 is four times greater in Greenland than in Denmark.

I am not a strict vegetarian, but I eat very little meat. My experiments have proved that health and strength can be maintained on a diet of whole grain bread, fat, potatoes and fruit, and experience has proved the same thing a thousand times. This fact possesses great interest in these times of threatened scarcity of food. Army rations are sometimes unsatisfactory because they are too complex. The Arabs live on bread and bananas and exhibit an endurance that the French and Italians find difficult to overcome. The daily ration of the Sikhs of India, reputed to be the best soldiers in the world, consists of about one pint of milk, 25 ounces of meal, 2 ounces of butter, 4 ounces of beans, and 5½ ounces of potatoes. They eat meat only two or three times a month.

* Abstract of Dr. Hindhede's article in *Die Umschau*. Translated for the Scientific American Supplement.

Measurements of Radium

In the recently issued circular of the Bureau of Standards on fees for various tests and investigations the following information in regard to radium is given.

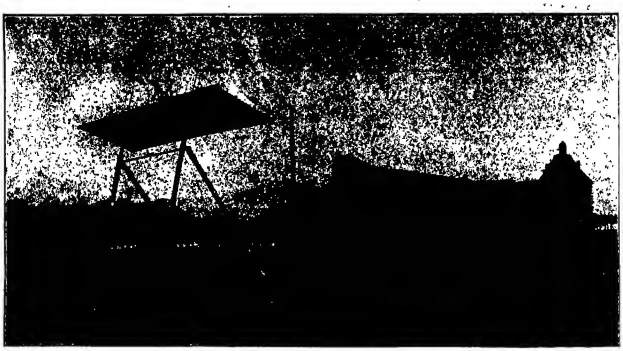
As recommended by the International Commission on Radium Standards, all determinations of the radium content of hermetically sealed specimens are based upon a comparison of the penetrating gamma radiation of the specimens with that of the standard.

This penetrating radiation proceeds not from radium itself, but from radium—C, one of the disintegration products of radium. Consequently, if the products of disintegration are entirely removed when the salt is sealed, there will at first be no penetrating radiation whatever; a measurement will give no indication of the presence of any radium in the specimen. Owing to the continual disintegration of the radium atom, the products of disintegration will at once begin to accumulate and at the end of four days radium—C and consequently its penetrating radiation will have reached about one half of its equilibrium value; and at the end of a month it will be within a half of a per cent of its equilibrium value. After equilibrium is reached the amount of radium -C in the specimen remains constant; or, rather, to be exact, it decreases at the same rate as radium disintegrates, namely, about one half in 2,000 years.

On the other hand, if only radium emanation (a gaseous disintegration product of radium) is sealed in a tube, the amount of radium -C which is in equilibrium with the amount of emanation will be formed almost immediately, and an observation will show the presence of an intensity of the penetrating radiation which is equal to that emitted by a tube which contains a certain amount of radium and which has been sealed for over a month. That is, a tube containing no radium may give a penetrating radiation equal to that given by a tube containing radium.

If the tube containing only radium emanation and its disintegration products is observed again four days later, its penetrating radiation will be found to be only one half of what it was before; after a month the radiation will have practically disappeared.

Thus, it is evident that no conclusion as to the amount of radium in a tube can be drawn from measurements made upon a single day. The actual amount of radium may be either greater or less than that indicated by the observed intensity of the penetrating radiation.



Aerotechnic Institute of Saint-Cyr, view of first platform equipped for a trial.

European Aeronautical Laboratories—I*

Their Organization, Equipment and Methods of Investigation

By A. F. Zahm, Ph.D.

During August and September, 1913, in company with Jerome C. Hunsaker, Assistant Naval Constructor, U. S. N., I visited the principal aeronautical laboratories near London, Paris, and Göttingen, to study, in the interest of the Smithsonian Institution, "the latest developments in instruments, methods, and resources used and contemplated for the prosecution of scientific aeronautical investigations."

These establishments resemble each other in some important features, but differ in others. All are devoted to both academic and engineering investigations. All are directed by highly trained scientific and technical men. The directors are not merely executives; they are the technical heads—scientists or engineers specifically qualified by superior training in aeronautical engineering and its immediately cognate branches—who initiate the researches, and assist their technical staffs in devising apparatus, interpreting results, and making systematic reports.

The establishments differ in their organization, resources, and equipments, and, to a considerable extent, in the scope and character of their investigations. Of the five institutions mentioned, the one in England and the one at Göttingen are now supported largely by governmental appropriations; and the other three are maintained by private capital, allotted as required, or accruing from fees or endowment funds. Again, the laboratories near London, at St. Cyr, and at Adlershof are practically unlimited in the scope of their researches, while Eiffel's and the Göttingen laboratory have confined their activities substantially to wind-tunnel experiments.

The aeronautical researches of the British government are in charge of the British Advisory Committee for Aeronautics, a self-governing civilian organization which was appointed by the Prime Minister of England to work out theoretical and experimental problems in aeronautics for the army and navy, and comprises twelve to fourteen expert men, under the presidency of Lord Rayleigh. This committee initiates and directs investigations and tests at the Royal Air Craft Factory, at the National Physical Laboratory, at the Meteorological Office, at Vickers Sons & Maxim's, etc. It expends, in performing its regular functions, a sum exceeding the income of any private aeronautical laboratory, and received directly from the government treasury.

The committee is primarily occupied with work for the government, but also performs researches and tests for private individuals, for suitable fees, but without guaranteeing secrecy as to the results. The work of the committee is manifold and comprehensive. Whirling-table measurements, wind-tunnel measurements, testing of engines, propellers, woods, metals, fabrics, varnishes, hydromechanic studies, meteorological observations, mathematical investigations in fluid dynamics, the theory of gyroscopes, aeroplane and dirigible design—whatever studies will promote the art of air craft construction and navigation may be prosecuted by this committee. A detailed programme and the results of actual investigations have been published in the annual report of this committee.

M. Eiffel has paid from his personal fortune all the expenses of his plant and elaborate researches, though it is understood that he may sometimes charge nominal fees for investigations made for private individuals who wish exclusive rights to the data and results obtained. The general director of the laboratory is Eiffel himself—who initiates the researches and publishes the results. He has in immediate charge two able engineers, MM. Rith and Lapresle, aided by three trained observers who are skilled draughtsmen. Two mechanics and one janitor complete the personnel. The work of the laboratory is all indoors, and is confined to researches in aerodynamics alone, or more specifically to wind-tunnel measurements and reports thereon.

The institute at St. Cyr was founded by Deutsch de la Meurth, who gave $100,000 for the original plant and has provided $3,000 per year, during his life, for maintenance. It was presented by him to the University of Paris, and is now under the general direction of the professor of physics, M. Maurain, aided by a technical staff and a large advisory council of eminent engineers, scientists and officers of the university, officers of the French government and members of various clubs and aeronautical organizations. The staff comprises the director in charge and his assistant, together with such students, two or three at a time, as may come as temporary volunteers from the University of Paris.

The institute conducts large-scale experiments in the open fields as well as indoor researches, makes investigations for general publication or for private interests, on payment of suitable fees, and permits private persons to conduct researches in the laboratory. The scope of the work is practically unlimited, as is the case in the English aeronautical laboratories. A special feature of the institute is its three-quarter mile long track with electric cars for tests on large screws, large models and full-sized aeroplanes.

The Göttingen aerodynamical laboratory was begun as a private enterprise, but is now to be enlarged and maintained in part by financial aid of the Kaiser Foundation. The original building, with its wind-tunnel, was erected in 1908 after the plans of its director, Prof. Prandtl, of the University of Göttingen, at a cost of 20,000 marks.

ENGLISH AERONAUTICAL LABORATORIES.

Aeronautical laboratories used by the British government.—Of the various aerotechnical plants supervised or used by the British Advisory Committee for Aeronautics, we visited the one at the National Physical Laboratory, at Teddington, and the one at the Royal Air Craft Factory, at Farnborough; but not the meteorological stations, nor the plants of private concerns working for the committee, such as Vickers Sons & Maxim.

The National Physical Laboratory, which corresponds to the U. S. Bureau of Standards, is under the directorship of Dr. R. T. Glazebrook, F.R.S., chairman of the Advisory Committee for Aeronautics; its engineering department is directed by Dr. T. E. Stanton; and the subdivision of this assigned to aeronautic investigation is in general charge of Mr. L. Bairstow.

The part of the National Physical Laboratory devoted exclusively to aeronautics comprises the whirling-table house, the large wind-tunnel house and the small wind-tunnel house with its liberal space for minor apparatus. The parts available for aeronautics, but not exclusively devoted thereto, are the general grounds, the large marine model tank, the ample shops for wood and metal working, the store rooms, the offices and library, the heating and lighting system, etc.

The whirling-table house, a separate building, is a corrugated iron shed some 80 feet square, having an earth floor, and at its center a motor driven vertical shaft which supports a trussed horizontal arm and causes it to whirl at any desired speed, its outer extremity describing a circle about 60 feet in diameter, and carrying in steady flight any model that has to be tested. The most important use of this whirling table hitherto made seems to have been to prove what was demonstrated and published in America by myself about one decade previously, viz., that a suitably designed pressure-tube anemometer is competent to measure the velocity of a uniform air current accurately to one per cent, or less,[1] and needs no calibration when its readings are interpreted in accordance with Bernoulli's theorem. The whirling arm has also been used to test model screw propellers, but is not necessary for this work, and is much less convenient for the purpose than the wind-tunnel, as used by Eiffel, for example.

The large wind-tunnel house, a wing of the engineering laboratory, is a concrete structure 100 feet long, 40 wide and 30 high, having a wooden horizontal wind-tunnel placed equidistant from the side walls, and midway between floor and ceiling, and supported between concrete columns reaching from floor to ceiling.

The large tunnel is some 80 feet long and 7 feet square in cross-section from its mouth to its middle; it expands considerably through the rest of its length. Its larger extremity abuts against the end wall of the room, while its mouth stops well short of the opposite wall. At mid-tunnel, just aft the enlargement, is placed a low-pitch wooden screw actuated by a 30 horse-power electric motor, and designed to give a current of 60 feet a second in the fore part of the tunnel. The screw sucks the air of the closed room through the mouth of the tunnel, which is somewhat flaring, thence through a metal honeycomb, into the experimental part of the tunnel, where the models are placed for study. Thence the air flows into the expanded half of the tunnel, passing first through the screw, then laterally outward through innumerable holes in the tunnel wall, thence in uniform circulation through the unobstructed room till it curves again easily into the mouth

* Smithsonian Miscellaneous Collections, vol. 62, No. 3.

[1] The calibration made at the British laboratory is reported to be reliable to one-tenth of one per cent.

Aerotechnic Institute of Saint-Cyr. Garage of electric platforms.

at the opposite end. The air stream so produced is, where it emerges from the honeycomb, uniform in velocity at all parts of a section, at least to a fraction of one per cent, if due care be taken. The expanded and perforated part of the tunnel is said to be the final outcome of long months of trial and study by the technical staff, and has enabled them to produce the steadiest aerodynamic current in the world; thus removing one of the greatest difficulties in the accurate determination of the flow and pressure of air about wind models. The current velocity is reported to be uniform to one half per cent both in time and space.

The complete structure of the tunnel need not be delineated here, as it may be had better from the general plans and detailed working drawings which the director of the laboratory has kindly offered to furnish the Smithsonian Institution. It may be explained, however, that the "honeycomb," just within the flaring mouth of the tunnel, consists of crossed metal sheets forming, post-office-box-like, a tubular partition of many cells through which the air entering the tunnel is straightened and deprived of eddies. It may also be observed that a glass door is placed on the side of the tunnel, through which one may take observations, or enter to adjust the models to be tested.

The cost of the 7-foot wind-tunnel is given as about $2,000, and of its wind balance about $2,000. This, with an expenditure of $12,500 for the building, makes a total of $16,500 for the plant.

The velocity of the air flow in the unchecked current, near the model held inside the tunnel, is computed from the observed pressure difference between the inside and outside of the tunnel wall. The accuracy of this method was experimentally proved by me in 1902 at the request of the Navy Department, and, together with a mathematical proof, was set forth in the *Physical Review* the following year. It was there shown that the speed of air rushing steadily through a horizontal cylindrical tube from the quiet atmosphere of the room into a chamber at low pressure is, for ordinary transportation speeds, given truly to a fraction of one per cent by the formula $V=\sqrt{\frac{2g}{\rho}(p_o-p)}$, p_o-p being the pressure difference between the room and chamber, V the speed[8] of inrush, and ρ the nearly constant density. The method has since been adopted at Eiffel's laboratory and at the National Physical Laboratory.[9] This for the speed of flow; the direction may be shown by fine silk threads moored in the current, or by floating particles, fine streams of smoke, etc. In passing it may be mentioned that the direction of flow in the unchecked current is parallel to the tunnel walls truly to a fraction of one degree.

Prandtl's honeycomb in wind tunnel.

The pressure difference in question is found by connecting the interior of the tunnel wall by means of external nipple and hose to one branch of a U tube manometer whose other branch opens into the quiet air of the room; then observing the difference of level of the liquid in the two arms. Manometers are made in many forms, according to the accuracy desired. The English one, known as the "Chattock tilting gauge," made public in 1903, measures barometric pressure differences truly to one five hundred thousandth of an atmosphere. My gauge, made in 1902 on a different principle, was graduated to millionths of an atmosphere and for the most accurate measurements of static pressure differences was always read to tenths of a graduation. At Eiffel's laboratory, and at various other places, a less accurate, but somewhat similar, manometer gauge is used. It consists merely of an inclined alcohol tube suitably mounted beside a graduated scale. The latter instrument, a long known type of gauge, I would recommend for its convenience; but where great precision is required the English gauge or mine would perhaps serve better.

Such gauges are equally useful for measuring the difference between some standard pressure and the actual pressure at various points on the surface of a model, or elsewhere. Thus one arm of the U tube may be connected with the internal surface of the tunnel while the other arm is connected successively to various points on the surface of a model. The difference between the standard wall pressure and that at each point of the model surface may then be plotted, giving a diagram of surface pressure distribution all over the model.

The wind balance.—Besides the pressure distribution and resultant pressure on models, it is desirable to determine also the total wind force, which is composed of both the pressure and the friction of the air. To this end the English experimentalists use a bell-crank balance which is a modification of the type devised and used in my laboratory, and now employed also by Eiffel for the accurate measurement of small wind forces. The English balance consists of two horizontal weighing arms, one parallel to the tunnel, the other perpendicular, attached to a round vertical tube, or arm, supported at its center on a conical pivot just beneath the tunnel floor. The vertical arm of the bell-crank balance has its upper

[8] More strictly speaking, V is the *increase* of velocity of the air as it flows from the room into the tunnel; but as the air starts from near rest, the increase of velocity is practically the whole velocity of inflow. A considerable error may ensue if V be taken as the true speed of inflow for the case of a tunnel of goodly section as compared with that of the room. Thus for the new English tunnel the cross-section is 7 x 7 feet in a room whose section is 30 x 40 feet. Hence the average speed of flow through the room is 4 per cent of the speed through the tunnel. Hence something like 4 per cent must be added to the speed computed from the true static pressure difference in question.

[9] At the National Physical Laboratory, the velocity along the axis of the tunnel as computed from the pressure difference inside and outside the tunnel wall is corrected by use of a small calibration constant obtained by placing a Pitot tube in the center of this tunnel before the place where the models are tested.

Experiment room, Eiffel Aerodynamical Laboratory.

Water channel at National Physical Laboratory, England.

half extending through the tunnel floor up to the center of the current and is duly shielded by a stream-line incasing sheath, while its lower half extends downward from the pivot and dips into a pail of oil intended to damp the oscillations. The upper half supports at its extremity the wind model and near the pivot has a graduated joint, so that it can be rotated about its own axis, and thus orient the model as desired. Sliding weights on the two weighing arms are made to measure the components of wind force parallel to the flow and perpendicular thereto. If the wind force tends to rotate the balance about the vertical axis, this tendency, or wind moment on the model, is determined by observing what horizontal restraining force must be applied to one of the horizontal arms to prevent such turning. Thus the balance may be used to measure lift, drift and center of pressure. There are numerous ingenious and important details, such as those for studying stability coefficients, which can best be obtained from the British Aeronautical Committee's technical report for 1913, or from the working drawings which the laboratory has furnished the Smithsonian Institution. Though this aerodynamic balance is accurate and moderately convenient, I am of the opinion that several new types can be devised which shall be equally precise and probably more expeditious, requiring less adjustment at each change of model. Such new types I have had in contemplation since first devising the bell-crank aerodynamic balance, in 1902.

The small wind-tunnel house, a wing of the engineering building, is of structural iron and covers rather more space than the room just described. Its chief apparatus is a 4-foot wind channel for testing small models. Other apparatus in this room are an engine testing plant, now dismantled; a horizontal water channel, described in the Advisory Committee's report for 1912-13; and a small vertical tube down which tobacco smoke, formed at its top, can be sucked by an up-draught in a parallel pipe beside it having a burning gas jet in the bottom to maintain a heated column, the purpose of the descending air mingled with the smoke being to delineate the flow about models immersed therein and visible through the glass sides of the tube.

The small wind-tunnel is the working prototype of the 7-foot tunnel already described. Made of one inch lumber, it measures some 40 feet in length and is supported more than 6 feet above the floor by heavy angle iron trestle work which also forms the framing for the wooden tunnel wall. The first half of the tunnel measures 4 feet square; the second half, joined to it by an expanding metal cone, measures 6 feet square, is thickly perforated with inch square holes in its side, and has its farther end abutting against the brick wall of the room. In the expanding cone at mid-tunnel is a low-pitch four-blade wooden screw driven by a steel shaft proceeding from a 10-horse-power electric motor on a wall bracket at the large closed end of the tunnel, and capable of maintaining an air current of 40 feet per second in the 4-foot tunnel. The character of the air flow and the instruments used are practically the same for the small as for the large tunnel. Some $20,000 was expended in developing and constructing this small tunnel and its appurtenances.

The small water channel, some 4 inches square in cross-section, has been used to exhibit the stream-line flow about models of ships' hulls, aeroplane posts, inclined wing forms, etc. By photographing the stream, duly dotted with tiny particles of foreign matter, clear pictures of the stream-lines and eddies have been obtained. These serve to show what forms are likely to encounter least resistance in moving through a fluid. But it can hardly be supposed that the phenomena of flow about a model slightly submerged in a shallow stream of water are identical with those for deep submergence in the atmosphere, unless for very slow speeds.

Wind-towers.—On the ground to the west of the National Physical Laboratory buildings, two wind towers, each 60 feet high and provided with rotating platforms 20 feet long, are used to determine the flow and pressure of free air about large-scale models. The first results of such determinations were published by Dr. Stanton in the proceedings of the Institution of Civil Engineers for 1907, and later studies may be found in the reports of the Advisory Committee. The Smithsonian Institution can doubtless obtain a like service from the three tall radio towers in its neighborhood.

The Royal Air Craft Factory, under the direction of Mr. Mervin O'Gorman, member of the Advisory Committee, is adjacent to the headquarters and flying grounds of the Military Wing,[4] at South Farnborough. Its work is co-ordinated with the aeronautical researches of the National Physical Laboratory, and is professedly concerned with the scientific improvement of air craft construction, though in reality directed at times to the manufacture, on a large scale, of aeroplanes, propellers and parts of dirigibles. The factory construction and research are in charge of a civilian staff which co-operates with the Advisory Committee for Aeronautics in performing aerotechnical work for the naval and military branches of the aerial service. The close co-ordination of the Air Craft Factory with the Flying Corps and with the Advisory Committee is an obvious advantage to the progress of aerotechnics, which might be still further enhanced if all the experimental plants were in one locality as proposed for the United States.

Apparently no very sharp line separates the aerotechnical work of the Royal Air Craft Factory from that of the National Physical Laboratory. Both have a whirling table; both have an engine testing plant; both have studied the materials of construction; both design instruments. But this overlapping is not excessive. Broadly speaking, the laboratory investigates models; the factory full-scale air craft, parts and appurtenances.

The factory investigates, develops, manufactures, and tests air craft. It is a mammoth plant, covering many acres and comprising half a dozen large buildings. It is said to expend half a million dollars per year and to employ 700 men, 400 of them working on aeroplanes. It has facilities for producing daily one complete aeroplane, excepting the engine, which at present is bought elsewhere. Its air craft are systematically tested on the great flying field nearby, bearing instruments which reveal their complete working in practical maneuvers. One instrument alone, called the "ripograph," records simultaneously the angles of pitch, roll and yaw, the speed through air, the altitude, the three control movements and the time. The stress in the wires, the propeller thrust and the pressure distribution on the wings and other surfaces may likewise be recorded.[5] The establishment does in fact the work planned in the United States for both the field laboratory and the experimental air craft factory. But the Royal Air Craft Factory lacks some of the facilities planned for our plant, such as an expanse of water for testing naval aeroplanes, and the immediate accessibility of allied laboratories, workshops and other resources.

The result of the full-scale experiments has been to disclose the defects of the leading types of aeroplanes, and to indicate means of betterment. Substantial improvement has been made in the efficiency, stability, factor of safety and range of speed of the aeroplanes specially studied at the factory. The final outcome has been to produce a stable, efficient and safe biplane having a range of speed of 40 to 80 miles an hour. It is expected shortly that a standard control will be adopted after the best types have been given a comparative test. The type at present most in favor is the Deperdussin control, which rotates a wheel for warping, shoves it for elevating, and uses a foot lever for steering. Such practical full-scale work cannot be too strongly recommended for the Smithsonian Institution, especially if the army and navy will, as already intimated, furnish for such tests their typical air craft and their experienced pilots.

Other English aeronautical laboratories worth mentioning are those of the Northampton Polytechnic Institute, London, and of the East London College. For want of time I did not investigate these; but as their resources are very moderate and their reports have been irregular and meager, it is doubtful whether they contain any equipment materially worth adding to what has been hitherto described.

(*To be continued.*)

[4] It may be noted that the entire military aerial service of England is known as "The Royal Flying Corps," and is under general supervision of the Air Committee, itself a subcommittee of the Committee on Imperial Defense. The Flying Corps comprises at present four branches: The Central Flying School; the Naval Wing; the Military Wing; the Reserve. The Advisory Committee for Aeronautics is an independent body, appointed by the Prime Minister, and receiving its appropriations directly from the Lord of the Treasury.

[5] All these measuring and recording devices can be purchased from the Cambridge Scientific Instrument Company.

A Vibration Electrometer*

THE telephone and the vibration galvanometer have long been used to detect very small alternating currents and voltages. The telephone is very sensitive in the range of frequencies from 500 to 3,000 cycles, but has the disadvantage of responding to harmonics as well as to the fundamental. The vibration galvanometers are relatively insensitive to the harmonics, and are much more sensitive at the lower frequencies than is a telephone.

The sensitiveness of an instrument may be defined in terms of the *voltage* which must be applied to give unit deflection, or it may be defined in terms of the *current* which will give unit deflection. In order that either a telephone or a vibration galvanometer shall be very sensitive to an alternating *current*, it must be constructed of very fine wire. A limit is soon reached in this direction, due to the difficulties in making and handling very fine wire. A vibration electrometer will detect very much smaller alternating currents than either of the above instruments. Such an instrument has already been described by Greinacher,[1] although his description did not appear until after the instrument here described had been constructed. He adapted a Wulf electrometer, using a transformer in connection with the instrument.

The instrument here described is a modification of a quadrant electrometer. The need for it arose in connection with the measurements of very small capacities at low frequencies. By means of it, capacities of the value of a thousandth of a microfarad have been measured at 50 cycles with an accuracy about ten times greater than can be obtained by any vibration galvanometer in this laboratory. For smaller capacities, the advantage is still greater. However, it is useful only when the impedance of the bridge arms is very high, so that the current which flows through them is very small. Also it cannot be used at frequencies much above 100 cycles on account of the moment of inertia of the vane.

As the design is of such form as to make a mathematical treatment of its behavior rather simple, the equations governing its operation have been worked out in some detail.

The instrument consists of four metal plates set vertically in pairs, the diagonally opposite plates being connected. Between these a light aluminium vane is supported by means of a bifilar suspension. This vane is free to vibrate about a vertical axis. The plates correspond to the quadrants of a quadrant electrometer, while the vane corresponds to the needle. If an electrostatic charge is given to the vane, and an alternating electromotive force is applied to the plates, the vane will be forced to vibrate in the period of the applied electromotive force. If the natural period of the suspended system is identical with the period of the applied electromotive force, then the amplitude of vibration is largely increased. The natural period can be varied by changing the length of the bifilar suspension, by varying the distance between the suspensions, or by altering the tension on the suspensions. When in resonance, the amplitude will depend upon the damping, and as air damping is a large part of the total damping, the whole instrument is placed under a bell jar, from which the air can be exhausted.

This instrument is capable of detecting alternating currents of low frequency having a value as small as 10^{-14} ampere. The conclusions verified by experiment are as follows:

For any given adjustment of the instrument, the frequency at which maximum deflection is obtained depends upon the potential of the vane. As the potential of the vane is increased, the frequency at which maximum deflection is obtained is decreased.

When the voltage on the vane is increased, the deflection for a given voltage on the plates increases more rapidly than the first power of the voltage. The sensitivity cannot be increased indefinitely in this way, since the frequency will become zero before the sensitiveness becomes infinite.

The deflection is inversely proportional to the damping. It is shown experimentally that the damping due to a well-constructed suspension is exceedingly small.

As the damping is decreased, the range of frequencies over which the instrument can be used is greatly diminished. Hence, it is not important to decrease the damping beyond a reasonable point.

Upon closing the circuit or otherwise changing the current through the electrometer, some time is required before the amplitude of vibration becomes constant. This time will be increased as the damping is decreased.

The power required to give unit deflection when the applied electromotive force is in resonance with the instrument decreases in the same ratio as the damping.

* *Bulletin of Standards*, No. 239, by Harvey L. Curtis, Associate Physicist.

[1] *Phys. Ze.*, 13, pp. 388, 433; 1912.

Removing Tar from Gas

THE problem of removing all traces of tar from the gas has always presented certain difficulties, and from experiments recently carried out it would seem that an electrical method is likely to solve the problem. The principle introduced is similar to that used in the smelting industry for the precipitation of lead and other fumes. A specially constructed electrode, from which high-tension direct-current discharges emanate, is suspended in a cast iron inverted U-tube, constructed from standard 8-inch pipe covered on the outside with a jacketing of felt. The arms of the U-tube are each 9 feet long. The electrode consists of two cast iron disks 4-inch diameter and placed 5 feet 8 inches apart, connected by means of a light gas pipe. Fine discharge wires are stretched from disk to disk in the form of a squirrel cage. The high-tension discharge has the effect of causing all the tiny particles of tar to be precipitated.

The Telephotographic Apparatus of Georges Rignoux

Experiments in Sending Visible Forms by Electricity

By R. Arapu

THERE is so much interest in television that the accompanying report of progress in the experiments of Dr. Georges Rignoux will be of timely value. The photographs, while by no means perfect, are new, having thus far been published nowhere in Europe or America, and will serve to show precisely what is being done.—EDITOR.

FOR a very long time physicists have been trying to solve the problem of seeing at a distance and as science has already made such marvelous conquests—the telegraph, the wireless sending signals, and the telephone conveying the sound of the voice to a distance, and now also without the intervening wire, that television, seeing at a distance, seems no longer merely an impossible dream.

The present story has to do with some experiments which Prof. Ruhmer in Berlin, Edouard Belin at Paris, and Georges Rignoux at la Rochelle, have been conducting. These have been in progress for some years, and have just reached a stage that is filled with interest, for it has been possible to recognize simple form reproductions transmitted by electric impulses in a distant city.

Rignoux, who is a young physicist of la Rochelle, sometime since devised an apparatus to which he gives the name Telephote, but which required a large number of wires, as many as there were of luminous points constituting the original image. Latterly, he has been able to simplify the Telephote to a marked degree, and just as the telephone transmits over a wire gradations and quality of sounds so the Telephote will transmit the lights and shadows for the defining of an illuminated image.

The Telephote requires two wires between the sending and receiving stations, in addition to one for synchronizing the machines at the two places, and is based on the general principles illustrated in the accompanying diagram. A suitable concave mirror, parabolic by preference, concentrates upon the object whose image it is desired to transmit the beam of a Nernst lamp of 2,000 candle-power, and the image of the original, thus illuminated is projected by means of a lens upon a mosaic of 64 cells of selenium. It is not necessary here to do more than note that the electrical resistance of selenium varies according to the amount of light which it receives, a property which has caused it to be made the foundation of many experiments of the kind.

Such a mosaic is capable of transmitting various figures and combinations of signs, the current passing to the selenium being of 110 volts. Each cell that is illuminated attracts the armature of its own electromagnet, but if there is no light there is no movement of this armature. The result of the projection of an image upon the mosaic will be that certain cells close armatures that permit currents to flow, and these currents are sent to a "collector" which rotates at 450 turns a minute, and the collected currents are delivered to the line by this device.

At the receiving end the impulses are conducted to a solenoid or coil, the axis of which is hollow. The beam of an arc light is directed by condensing and projecting lenses upon a nicol prism, and then passes through the solenoid. When it emerges it comes upon a second nicol prism that is reversed to the first, and the normal result is that the second prism entirely stops the light already polarized by the first. The effect of the current through the solenoid is, however, to change the plane of polarization of the beam of light, and make it possible to pass the second nicol. It is then caught by a lens, passed through a diaphragm which holds back all but the central rays, and these fall on mirrors fixed to the periphery of a wheel. A convenient screen receives the reflections from the turning mirrors, and on this screen will be seen the transmitted image of the distant original.

Dr. Rignoux has succeeded in sending in this way, by means of the Telephoto in his laboratory, the images of the letters of the alphabet, H, T, L, and U among them, and the photographs shown are taken from these images. By removing the screen the eye can catch the images on the mirrors but not as sharply.

Thus far these investigators have not attempted to send any half-lights, but are now experimenting with this end in view. To obtain an image of a person it will be necessary to have a selenium mosaic of from 3,000 to 4,000 cells. It is believed also that in time the receiving screen will not be necessary, and when this is dispensed with the image formed will be much stronger and clearer. The present intensity of this image is weak. Dr. Rignoux and his associates do not claim that the problem of television is solved, but the report that they make is an interesting statement showing that important advances have really been made.

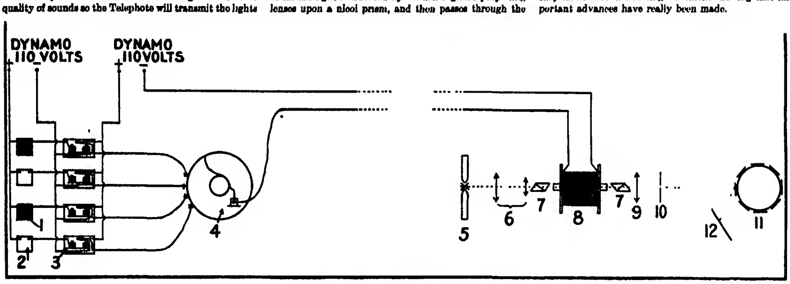


Diagram of the Rignoux telephotographic apparatus.

1. Selenium cell not illuminated. 2. Selenium cell illuminated. 3. Electromagnets (relays). 4. Relay collector 5. Arc light 6 Projecting lenses and condenser 7 Nicol prisms 8. Solenoid. 9. Projecting lens. 10. Diaphragm. 11. Revolving mirrors. 12. Screen receiving image.

The Coolidge Tube in Metallurgical Research*

By Dr. Wheeler P. Davey

DR. WEINTRAUB in the February, 1913, number of the *Journal of Industrial and Engineering Chemistry* describing boron and its compounds says:

"Boron suboxide, a by-product obtained in the manufacture of boron, can be used for obtaining high conductivity cast copper. Copper cast without additions is full of pores and blowholes, and therefore mechanically unfit and of very low electric conductivity; the removal of the gases from copper by the known deoxidizers is liable to give an alloy containing a small amount of deoxidizer, an amount sufficient, however, to lower the conductivity of the copper very considerably. Boron suboxide, however, has the property of deoxidizing copper without combining with it, as boron suboxide has no affinity for copper.

In the refining of copper for electrical purposes, the electrically deposited metal is melted in a reverberatory furnace. A world of delicate chemical control is connected with this furnace refining.

If the metal were merely melted and then poured the casting would be full of blow-holes and would be of low electrical conductivity. The molten copper is allowed to oxidize in the furnace and the oxidation is augmented by air blown into the metal. When the melt contains 5 or 6 per cent of oxide, the major part of the other impurities have been burned away and the work of reduction is started. As ordinarily done, this consists in the so-called "poling." Green sticks are submerged in the molten copper and the gases and carbon reduce the oxide, and such harmful products as sulphur dioxide are driven out of the metal. The proper time for pouring is not that representing complete reduction of all oxide, as it has been determined by experience that over-poling also gives a porous inferior ingot.

It was once believed that the copper absorbed carbon which in over-poled copper caused the rising in the mold and the porous condition when cast. Hampe corrected this idea and attributed the porous state of over-poled copper to the effect of absorbed hydrogen and carbon monoxide.

The use of the boron flux of Weintraub has done away entirely with the difficulty of obtaining sound castings of high electrical conductivity. It seemed interesting to illustrate the effect on the porosity by an investigation using X-rays. For this purpose some high grade copper was melted in the usual way and poured into a sand mold to give a block 10 by 10 by ¾ inches. Another portion was treated with one per cent of the boron flux at the time of pouring and was cast in a similar mold. These two castings were then placed side by side on an 8 by 10-inch Seed X-ray plate, 22 inches from the focal spot of a Coolidge X-ray tube and exposed for two minutes. The current through the tube was 2.8 milli-amperes and the potential difference across the tube corresponded to a 10-inch parallel spark gap between points. The resulting radiograph showed the copper cast in the ordinary way to be full of pores. The cast with the boron flux was so perfect that no holes were visible. The two castings were then taken to the machine shop and a portion of the surface of each was machined as smooth as possible, and, as was to have been expected from the radiographs, the holes were clearly visible in the common copper, while in the "boronized" copper the holes were either entirely absent or were microscopic.

The advantage of the radiograph in experimental work is obvious. Without the use of X-rays it is necessary to machine off layer after layer of the sample in order to expose to view any hidden defects. Even when this is done it remains for the experimenter to build up a mental picture of the defects in his casting on the basis of what he has seen on each of the exposed layers. From the radiograph it is possible to see *all of these defects at once* without destroying the casting. If it seems desirable, it is easily possible to make stereoscopic radiographs whereby the defects may be seen in their entirety and their depths easily estimated.

In view of the results shown above, the X-ray examination of metals as a means of metallurgical research seems to have certain attractive and desirable features not found in other methods and to open a wide field for further work.

*From the *General Electric Review*.

(Note: Two other articles describing practical and commercial uses of this new tube have appeared in the SCIENTIFIC AMERICAN SUPPLEMENT, as follows: "Applications of the Coolidge X-ray Tube," in No. [illegible], for September 12th, 1914; and "An X-ray Examination of a Steel Casting" in No. 2040, for February 6th, 1915. Copies of these can be supplied at 10 cents each.)

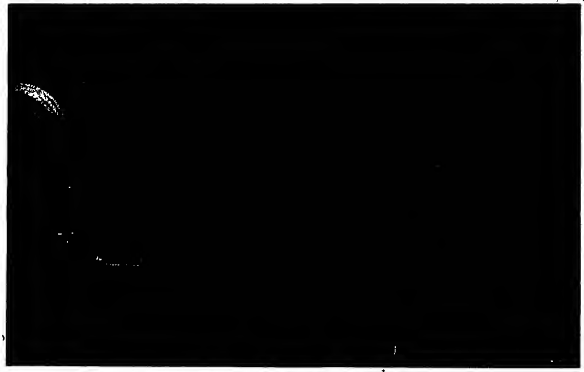


Fig. 1.—Important parts of machine used for winding wire on a 14-inch gun.

Wire-Winding Big Guns for Uncle Sam*

Methods by Which the Most Powerful Guns in the World Are Made

By Chester L. Lucas

The strengthening of artillery by wire-winding is a subject that has received the attention of ordnance experts for years. There are many different opinions as to the merits of wire-wound guns, and they have been freely expressed by authorities in this country and abroad; therefore, it will not be attempted in this article to discuss wire-wound guns from the engineering standpoint, but rather to describe the details of the operation of applying the layers of wire to the gun as done in the United States Arsenal at Watervliet, N. Y.

The antiquity of the principle of reinforcing guns with wire is evidenced by an early cannon now in the museum at the Woolwich Arsenal in England, that is said to have been used by Gustavus Adolphus early in the seventeenth century. This cannon is about six feet in length, with a copper barrel, and is reinforced by being wound with hempen cord and then covered with leather. The practical application of this principle to modern warfare, however, commenced about 1850, with the efforts of Longridge in England and his contemporary Woodbridge in America. Since that time, the wire-wound gun has been used to a growing extent in Great Britain and Europe, but it is only during the past eight years that wire-wound guns have received official recognition in the United States. At the present time the wire-wound gun is used for coast defense only.

THE PRINCIPLE OF THE WIRE-WOUND GUN.

Before taking up the operation of wire-winding, a few words on the principle involved may not be amiss. Many years ago it became apparent to ordnance experts that a gun built up of successive tubes shrunk in place was far superior to a gun made from a solid billet. Under the gas pressure of firing, it was found that the metal nearest the bore of a solid gun was stretched beyond its elastic limit, while the outside metal was unaffected, receiving none of the strain. Therefore, no matter how thick the walls of the gun were made, the inner metal around the bore was the only part that received the gas pressure, and as soon as this metal became fatigued the gun was unfit for use. By building the guns of tubes, successively shrunk one over the other, it was found possible to close in the metal of the inner tube by shrink-pressure of the outer tubes so that when the gun was fired the metal of the inner tube had to be first expanded back to its natural condition and then stretched beyond its elastic limit before being fatigued. As the succeeding layers of these tubes were shrunk in position, this stretching of the inner tube was resisted by the pressure of each of the outside bands, and consequently the life of the gun was greatly lengthened; in addition, it was possible to build a much lighter gun of the same relative strength as the solid gun. From the above it will be seen that the winding of guns with wire that is under tension brings about the same condition as is obtained by shrinking on tubes successively, and it is claimed that the use of high tensile strength wire gives the gun strength attainable in no other way.

There are two principles employed in applying wire to guns, one of which consists in winding successive layers of wire at the same tension. The second system consists in winding the wire at a varying tension, decreasing with each successive layer. The first system is, of course, applied with the minimum amount of trouble, but it is claimed that the second principle has the advantage of distributing the firing strain in as nearly uniform a manner as possible.

Fig. 2 shows a sectional view of the Crozier type of wire-wound gun, reproduced from "Ordnance and Gunnery," by Capt. L. L. Bruff. This view is reproduced to illustrate the manner in which the layers of wire are distributed over the length of the gun. In each series of reinforcements, about ten layers of wire are applied. At the breech end of the gun, the reinforcement is heaviest. At the muzzle end the layers are fewer in number, but the wire is put on at a higher tension in order to give the necessary strength with the smallest amount of wire. Covering tubes are shrunk in place over the wire and each of these tubes is "stepped" so that it has a bearing on one of the adjacent tubes as well as on the layers of wire.

The wire used for this work in the United States is square in section, being one-eighth inch diameter with slightly rounded corners. The English and Continental practice employs for the most part wire of rectangular section. The material is cold-drawn steel, having a tensile strength of 180,000 pounds per square inch and an elastic limit of 140,000 pounds per square inch. Its quality is an all-important factor, and is maintained by rigid physical and metallurgical tests.

THE WIRE-WINDING APPARATUS.

Fig. 1 illustrates the operation of winding wire on a 14-inch gun. The work is done in a large gun lathe, and the gun itself is rotated, drawing the wire from the wire-reel as it is wound on the gun. Between the gun shown in Fig. 1 at *A* and the reel *B* is the tensioning mechanism. A similar tensioning mechanism is shown in Fig. 3, although the details of the latter are slightly different from those in Fig. 1. Both views, however, illustrate the principle. The wire, as it leaves the reel, passes over an idler *C* and thence between the two friction disks which are indicated at *D*. A guide wheel *E* is in contact with the edge of the friction disk, and insures that the wire enters properly.

When the wire passes between the halves of the friction disk, it just fits into a square recess, half of which is cut in each disk. A very powerful spiral spring presses the halves of the disk constantly on the sides of the wire, and it is one of the functions of guide wheel *E* to force the wire into the groove cut in the friction disk. The wire runs around the friction disks, being in contact for nearly three fourths of the circumference, and then passes over the fixed pulley *F*. From there it runs down over the floating pulley *G*, forming a loop, and back again over another groove in pulley *F*. The arrangement of pulleys *F* and *G* is much the same as in the familiar block and tackle. Pulley *G* that floats in the loop of wire has suspended from its center a lever *H* that is pivoted on the extreme left-hand end, and on the extreme right-hand end of the long arm is hung the heavy weight *I*, shown only in Fig. 1. The weight on this lever may be varied, of course, to change the tension on the loop of wire, but in the illustration Fig. 1 this weight is 240 pounds and the leverage is so compounded that there is a pull on the wire amounting to 625 pounds. From these figures it may be seen that the wire, as it is wound on the gun, is under a tension of 40,000 pounds.

On the shaft with the friction disk is a brake drum that, in connection with two brake-bands, one of which is shown at *J*, impedes the rotation of the shaft. The object of having two brake-bands is to regulate the "drag" that is being applied to the wire. The wider

* From *Machinery*, by Chester L. Lucas, associate editor.

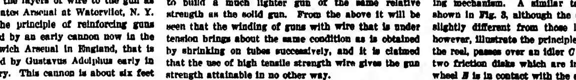


Fig. 2.—Section of Crozier type of wire-wound gun.

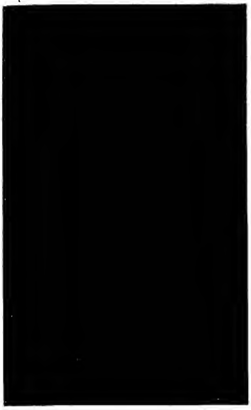


Fig. 3.—Mechanism for obtaining tension in winding wire.

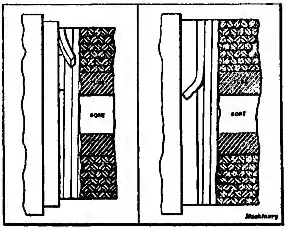


Fig. 5.—Diagram showing application of wire to gun. Fig. 6.—Method of securing end of strand.

Fig. 4.—Wire wound onto gun.

of these bands is kept at a fixed tension, and the narrower is adjusted when increased or decreased drag on the wire is desired. The action of the brake and bands generates considerable heat, and to dissipate this, a stream of water passes through the center of the brake drum. The pipe for this purpose may be seen in the illustration, Fig. 3, entering the center of the axle at *L*. The drag of the friction upon the wire, on the one hand, and the pull of the wire as it is drawn onto the gun, on the other hand, support the wire while the tension is being secured. The compounded weight *I* that pulls upon the loop of wire around pulleys *F* and *G* gives this tension.

This lathe is geared so that the carriage holding the tensioning mechanism, wire and reel travels at the rate of one eighth inch to each revolution of the spindle. As the wire is exactly one eighth inch in diameter this, of course, is the proper lead. In order to make sure that the wire is wound closely, a spring finger bears against the strand of wire just before it is laid in place upon the gun. This insures that it is crowded over against the convolution previously applied. This may be seen on a large scale in Fig. 4. The wire is wound on the gun at the rate of from 120 to 240 feet per minute.

"FILLING IN" AT THE END OF THE LAYERS.

At the end of each layer of wire it is obvious that there will be a space that the wire cannot fill on account of the fact that the turns are helical. This space is one eighth inch wide at the beginning and tapers down to nothing at the end of the revolution, but even this slight space must be filled to complete the layer and form a good foundation for the next layer of wire. A strip of wire long enough to go around the gun is tapered for its entire length from one eighth inch at one end to nothing at the other end. This is also tapered for about an inch at the thick end to fit in under the strand of wire as it passes up to the next layer. These points are clearly shown in Fig. 5. This length of tapered wire is carefully driven into place and the new layer started on its course. At the beginning of this new layer it is also necessary to insert another filler wire to close up the space left. Thus two filler wires are required for each layer of wire wound. As these filler wires are several feet long and only one eighth inch square at the heavy end, it is rather difficult to hold them for planing the taper from end to end. The type of planing fixture used supports the wire on three sides, being clamped at six-inch intervals. Only the top is left open and but one wire is planed at a time.

When joining the end of one reel of wire to a new reel, the connection is made by electrically soldering with hard solder. The two ends of the wire are scarfed and clamped in the copper faced terminals of the electric heating fixture. Between the scarfed ends of the wire, a piece of sheet silver solder is placed and the joint well fluxed with a borax paste. The current is then turned on and ten seconds heats the ends, flows the solder, and completes the joining, and there is none of the "fuss" usually experienced when the blow-pipe is used.

On starting the strand of wire, the end is driven into a hole or recess in the gun body, and the end of the strand of wire on the last layer is also secured by being driven into a chiseled groove cut into the solid metal. The method of securing the end of the strand is illustrated in Fig. 6, and the groove is made small and deep enough so the wire can be driven down into it and the edges of the groove peened over onto the top of the wire, thus bolting it effectually.

After all the wire of the gun has been wound in place, a very light lathe cut is taken over the top layer, leaving the outside perfectly smooth so as to form a good surface upon which the next steel jacket may be shrunk. As the wire is cold-drawn to within limits of 0.001 inch there is very little unevenness, especially in view of the fact that it is under such high tension while being wound. The gun is now ready for the shrinkage on of the rings or covering tubes. The tubes are bored out to the external diameter of the wire, minus the allowance for shrinkage. Then, with the gun in a vertical position, breech down, and a stream of water within the bore to keep it cold, the shrink rings or tubes are heated and dropped into place. It may be well to draw attention to the fact that the shrinking on of these covering tubes is a very important operation and is done with great care.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

It would seem that the following account of the first American submarine would be of interest at this time. This narrative is taken from *The American Journal of Science and Arts*, volume II, published in 1820.

Glens Falls, N. Y. F. B. RICHARDS.

SUBMARINE NAVIGATION.

Article VIII. Description of a machine, invented and constructed by David Bushnell, a native of Saybrook, at the commencement of the American revolutionary war, for the purpose of submarine navigation, and for the destruction of ships of war; with an account of the first attempt with it, in August, 1776, by Ezra Lee, a sergeant in the American Army, to destroy some of the British ships then lying at New York. Communicated by Charles Griswold, Esq.

To Prof. Silliman:

LYME, CONN., February 21st, 1820.

Sir:—It is to be presumed that every person who has paid any attention to the mechanical inventions of this country, or has looked over the history of the revolutionary war, has heard of the machine invented by David Bushnell, for submarine navigation, and the destruction of hostile shipping. I have thought that a correct and full account of that novel and original invention would not be unacceptable to the public, and particularly to those devoted to the pursuit of science and arts.

If the idea of submarine warfare had ever occurred to anyone before the epoch of Bushnell's invention, yet it may be safely stated, that no ideas but his own ever came to any practical results. To him, I believe, the whole merit of this invention is unanimously agreed to belong.

But such an account as I have mentioned must derive an additional value and an increased interest from the fact that all the information contained in the following pages has been received from the only person in existence possessed of that information, and who was the very same that embarked in this novel and perilous navigation.

Mr. Ezra Lee, first a sergeant and afterward an ensign in the revolutionary army, a respectable, worthy, and elderly citizen of this town, is the person to whom I have alluded; to him was committed the first essay for destroying a hostile ship by submarine explosion, and upon his statements an implicit reliance may be placed.

Considering Bushnell's machine as the first of its kind, I think it will be pronounced to be remarkably complete throughout in its construction, and that such an invention furnishes evidence of those resources and creative powers which must rank him as a mechanical genius in the first order.

I shall first attend to a description of this machine, and afterward to a relation of the enterprise in it by Sergt. Lee, confining myself in each case strictly to the facts with which he has supplied me.

Yours, etc.,
CHARLES GRISWOLD.

Bushnell's machine was composed of several pieces of large oak timber, scooped out and fitted together, and its shape my informer compares to that of a round clam. It was bound around thoroughly with iron bands, the seams were corked, and the whole was smeared over with tar, so as to prevent the possibility of the admission of water to the inside.

It was of a capacity to contain one engineer, who might stand or sit, and enjoy sufficient elbow room for its proper management.

The top or head was made of a metallic composition, exactly suited to its body, so as to be water-tight; this opened upon hinges and formed the entrance to the machine. Six small pieces of thick glass were inserted in this head for the admission of light; in a clear day and clear sea-water, says my informer, he could see to read at the depth of three fathoms. To keep it upright and properly balanced, 700 pounds of lead were fastened to its bottom, 200 pounds of which were so contrived as to be discharged at any moment, to increase the buoyancy of the machine.

But to enable the navigator when under water, to rise or sink at pleasure, there were two forcing pumps, by which water could be pressed out at the bottom; and also a spring, by applying the foot to which a passage was formed for the admission of water. If the pumps should get deranged, then resort was had to letting off the lead ballast from the bottom.

The navigator steered by a rudder, the tiller of which passed through the back of the machine at a water joint, and in one side was fixed a small pocket compass, with two pieces of shining wood (sometimes called foxfire) crossed upon its north point and a single piece upon the last point. In the night, when no light entered through the head windows, this compass thus lighted

was all that served to guide the helmsman in his course

The ingenious inventor also provided a method for determining the depth of water at which the machine might at any time be. This was achieved by means of a glass tube 12 inches in length and about 4 in diameter which was also attached to the side of the machine this tube inclosed a piece of cork that rose with the descent of the machine and fell with its ascent, and one inch rise of the cork denoted a depth of about one fathom The principle upon which such a result was produced and also the mechanical contrivance of this tube entirely escaped the observation of Mr Lee amid the hurry and constant anxiety attendant upon such a perilous navigation.

But not the least ingenious part of this curious machine was that by which the horizontal motion was communicated to it This object was effected by means of two oars or paddles formed precisely like the arms of a wind mill which revolved perpendicularly upon an axletree that projected in front this axletree passed into the machine at a water joint and was furnished with a crank by which it was turned the navigator being seated inside, with one hand labored at the crank and with the other steered by the tiller

The effect of paddles so constructed and turned in the manner stated by propelling or rather drawing a body after them under water will readily occur to anyone without explanation

These paddles were but 12 inches long and about 4 wide Two smaller paddles of the same description also projected near the head provided with a crank inside by which the ascent of the machine could be assisted

By vigorous turning of the crank says my informer the machine could be propelled at the rate of about three miles an hour in still water When beyond the reach of danger or observation of an enemy the machine was suffered to float with its head just rising from the water's surface and while in this situation air was constantly admitted through three small orifices in the head which were closed when a descent was commenced

The efficient part of this engine of devastation—its magazine— remains to be spoken of This was separate and distinct from the machine It was shaped like an egg and like the machine itself was composed of solid pieces of oak scooped out and in the same manner fitted together and secured by iron bands etc One hundred and thirty pounds of gunpowder a clock and a gunlock provided with a good flint that would not miss fire were the apparatus which it inclosed This magazine was attached to the back of the machine a little above the rudder by means of a screw one end of which passed quite into the magazine and there operated as a stop upon the movements of the clock while its other end entered the machine This screw could be withdrawn from the magazine by which the latter was immediately detached and the clock commenced going The clock was set for running twenty or thirty minutes at the end of which time the lock struck and fired the gunpowder and in the meantime the adventurer effected his escape

But the most difficult point of all to be gained was to fasten this magazine to the bottom of a ship Here a difficulty arose which and which alone as will appear in the ensuing narrative defeated the successful operations of this warlike apparatus

Mr Bushnell's contrivance was this A very sharp iron screw was made to pass out from the top of the machine communicating inside by a water joint It was provided with a crank at its lower end by which the engineer was to force it into the ship's bottom this screw was next to be disengaged from the machine and left adhering to the ship's bottom A line leading from the screw to the magazine kept the latter in its destined position for blowing up the vessel

I shall now proceed to the account of the first attempt that was made to destroy a ship of war all the facts of which as already stated I received from the bold adventurer himself

It was in the month of August 1776 when Admiral Howe lay with a formidable British fleet in New York bay a little above the Narrows and a numerous British force upon Staten Island commanded by Gen Howe threatened annihilation to the troops under Washington that Mr Bushnell requested Gen Parsons of the American Army to furnish him with two or three men to learn the navigation of his new machine with a view of destroying some of the enemy's shipping

Gen Parsons immediately sent for Lee then a sergeant and two others who had offered their services to go on board of a fire ship, and on Bushnell's request being made known to them they enlisted themselves under him for this novel piece of service The party went up into Long Island Sound with the machine and made various experiments with it in the different harbors along shore and after having become pretty thoroughly acquainted with the mode of navigating it, they returned through the Sound, but during their absence the enemy had got possession of Long Island and Governors Island They, therefore, had the machine conveyed by land across from New Rochelle to the Hudson River and afterward arrived with it at New York

The British fleet now lay to the north of Staten Island with a large number of transports, and were the objects against which this new mode of warfare was destined to act The first serene night was fixed upon for the execution of this perilous enterprise and Sergt Lee was to be the engineer After the lapse of a few days a favorable night arrived and at 11 o'clock a party embarked in two or three whaleboats with Bushnell's machine in tow They rowed down as near the fleet as they dared when Sergt. Lee entered the machine, was cast off and the boats returned

Lee now found the ebb tide rather too strong and before he was aware had drifted him down past the men of war, he, however got the machine about, and by hard labor at the crank for the space of five glasses by the ship's bells or two and a half hours he arrived under the stern of one of the ships at about slack water Day had now dawned and by the light of the moon he could see the people on board and heard their conversation This was the moment for diving he accordingly closed up overhead let in water and descended under the ship's bottom

He now applied the screw and did all in his power to make it enter but owing probably in part to the ship's copper and the want of adequate pressure to enable the screw to get a hold upon the bottom his attempts all failed at each essay the machine rebounded from the ship's bottom not having sufficient power to resist the impulse thus given to it *

He next paddled along to a different part of her bottom but in this maneuver he made a deviation and instantly arose to the water's surface on the east side of the ship exposed to the increasing light of the morning and an imminent hazard of being discovered He immediately made another descent with a view of making one more trial but the fast approach of day which would expose him to the enemy's boats and render his escape difficult if not impossible deterred him and he concluded that the best generalship would be to commence an immediate retreat.

He now had before him a distance of more than four miles to traverse but the time was favorable At Governors Island great danger awaited him for his compass having got out of order he was under the necessity of looking out from the top of the machine very frequently to ascertain his course and at best made a very irregular zigzag track

The soldiers at Governors Island espied the machine and curiosity drew several hundreds upon the parapet to watch its motion At last a party came down to the beach shoved off a barge and rowed toward it At that moment Sergt Lee thought he saw his certain destruction and as a last act of defense let go the magazine expecting that they would seize that likewise and thus all would be blown to atoms together

Providence however otherwise directed it the enemy after approaching within fifty or sixty yards of the machine and seeing the magazine detached began to suspect a Yankee trick took alarm and returned to the island

Approaching the city he soon made a signal the boats came to him and brought him safe and sound to the shore The magazine in the meantime had drifted past Governors Island into the East River where it exploded with tremendous violence throwing large columns of water and pieces of wood that composed it high into the air Gen Putnam with many other officers stood on the shore spectators of this explosion

In a few days the American Army evacuated New York and the machine was taken up the North River Another attempt was afterwards made by Lee upon a frigate that lay opposite Bloomingdale his object now was to fasten the magazine to the sterns of the ship, close to the water's edge But while attempting this the watch discovered him raised an alarm and compelled him to abandon his enterprise He then endeavored to get under the frigate's bottom but in this he failed, having descended too deep This terminated his experiments

* It yet remains a problem whether the difficulty here spoken of will ever be fully obviated Mr Fulton's torpedoes were never fairly brought to the test of experiment, though he and his friends entertained perfect confidence that they would not be found defective in any of their operations.

Rifling Canon

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT

In a translated article from the *Umschau* in your current SUPPLEMENT Prof Adolf Keller states that the primary reason for rifling a projectile is to keep it end on explaining that otherwise it would bring up with its maximum surface against the line of flight, "just as a card brings up with its flat surface" I have shown that while this is true of a thin flat body, it is not true of a long fusiform body which, provided it has sufficient velocity, always tends to keep end on, e. g., a javelin or an untipped arrow

He further states that the phenomenon known as the "drift" of a rifled projectile is due to its rolling on a heavy cushion of air underneath it, and he says this is known as the "Poisson effect." I have made some examination to discover where this term originated, what it means and by whom it is known Poisson published most of his papers between 1800 and 1830. Very little of the theory of gyroscopic motion was known in his time Euler in 1780 had given his celebrated dynamic equations in gyroscopic motions and had stated he believed they were true but that he had no idea what the motion would be D'Alembert in 1700 said that he was thankful that although the motions were not yet discovered they had at least been presented in analytical form The first complete explanation of these motions was given by Poinsot in his "Theorie nouvelle de la rotation des corps," 1834.

In Poisson's time, ranges were too short and guns too imperfect for the "drift" to be perceptible The recognition of the drift came in with the more modern light powered guns As far as I can find, the discovery of and the name "drift" came in some time during the latter half of the last century If the term "Poisson effect" meaning I presume a rolling against frictional resistance is known it is certainly not well known The last edition of the Encyclopædia Britannica says "The cause of the drift is unknown but it is evidently due to some gyroscopic action

The latest standard work on the gyroscope in Germany is Klein & Sommerfeld's "Ueber des Theorie Kreisels" This was published in 1910 and I think any later edition improbable In this work an attempt is made to explain the drift as a gyroscopic phenomenon There have been several other such attempts but they have all failed Prof Mach of Vienna (1906) said that the axis of a rifled projectile must execute very rapid and complicated motions with peculiar condensation of air about the point but that their nature was not understood I worked out this problem in 1910 and published an explanation of the drift in 1913 * I there showed that it was due to the projectile rolling sideways on a heavy cushion of air beneath while above was a partial vacuum offering practically no frictional resistance I also showed that the point executes peculiar cycloidal curves being in fact a kind of double roulette Prof Keller states correctly in his article that the point executes cycloidal curves, and also that the drift is due to frictional rolling on a heavy cushion of air beneath the projectile He makes no mention of the vacuum above But I cannot understand the relevancy or necessity of calling this action a "Poisson effect"

This is the first correct explanation of the drift I have met with outside of my own What particularly interests me is when and where this independent explanation originated F J B CORDEIRO

Newton Center Mass

Cultivation of Living Tissues Outside the Body

THE story of the cultivation of tissues outside of the living body has already lost much of its novelty Though we can still easily count the time in terms of months rather than years the fact has been established so conclusively and the technic developed so successfully that the cultivation of tissues in this way has already become a familiar practice in many laboratories

Not long ago Carrel of the Rockefeller Institute for Medical Research called attention to the condition of a piece of connective tissue kept in a condition of permanent life It was derived originally from a piece of heart from a chick embryo The fragment pulsated for 104 days and gave rise to a large number of connective tissue cells which have since multiplied actively It has now been kept alive artificially for twenty nine months, according to *The Journal of the American Medical Association*, and shows greater activity than at the beginning of that period, and is no longer subject to the influence of time If we exclude accidents these connective tissue cells may live indefinitely

Keeping Steam Turbine Blades Clean

IN spite of treatment of the water used for steam purposes in a western electric plant, magnesia and lime were carried over in considerable quantities and formed a coating on the blades of the turbine that was difficult to remove and necessitated considerable work, besides the delays resulting from shutting down the machine. It was discovered, however, that kerosene would keep the blades clean, and a small hand pump for injecting it was fitted to the main steam pipe. Only an occasional dose of kerosene was necessary to keep the turbine blades clean and in good condition.

* See Gyroscope.

Pathology of Mental Diseases—II*

Modern Aspects of Certain Problems

By Edwin Goodall, M.D., Lond., B.S., F.R.C.P., Lond.

Concluded from Scientific American Supplement No. 2054, Page 307, May 15, 1915

MICRO-ORGANISMS AND TOXINS IN CONNECTION WITH MENTAL DISEASES.

The evidence furnished by the morbid histology of the brain in the acute and recent psychoses is not in favor of anything approaching a virulent toxæmia, with the doubtful exception of the condition known as "acute delirium," or "acute delirious mania"; neither does clinical evidence point to such, with the same possible exception. The temperature-pulse-respiration chart in cases of acute and recent mental disorders shows very little evidence of febrile reaction. Toxins, if any, must be of a low degree of virulence. We know, however, that various drugs which are incapable of producing the bodily disturbance of reaction which accompanies an attack of one of the specific fevers, and from this point of view are not virulent, are nevertheless able to produce very definite mental disturbance. While morbid histology affords practically no evidence of acute toxæmia in the psychoses, the changes found are quite compatible with the operation of a toxin of a milder kind. This is true, apart from dementia paralytica, for acute delirium, acute mania or melancholia, the psychoses of exhaustion. Cases of the disorders grouped under the name "dementia præcox" do not, for all practical purposes, come to necropsy in the acute and recent phase, so that, unfortunately, we have no sufficient information in respect to these. The examination of the blood in the acute and recent psychoses with the usual aerobic methods, upon the usual culture media, gives negative results.

Of all mental disorders the condition known as "acute delirium," or "acute delirious mania," is that in which we should most expect to find evidence of bacterial origin, on account of the acuteness of all the mental symptoms and the existence of grave bodily illness. The rarity of this condition has largely prevented its proper study; among the rate supported insane, at any rate, it is extremely rare, and I can only remember to have seen two or three cases in my experience of twenty-four years, and one of these was at Bethlehem Royal Hospital, which does not receive the rate supported. No significance is to be attached upon scientific grounds to any organism hitherto found in the circulation in this disease. The condition is seen in connection with typhoid and other infectious disorders, and it would therefore appear that more than one toxic agent can produce it, unless, indeed, such acts merely as a predisposing cause. Kosowsky[19] in a recent communication upon the pathology of acute delirium, states that staphylococci, diplococci, and the influenza bacillus have all been found in cases of that disorder, and this is not surprising, seeing that the state follows upon diseases in which these organisms are causal agents. I am not aware of any record of animal inoculations in connection with cases of acute delirium. The psychoses following upon specific fevers but rarely come to necropsy, so that we have no sufficient information as to the histological conditions present in the brain in such cases.

The Infection Psychoses.

This brings me to the consideration of the psychoses due to infection or intoxication processes. By these we mean disorders of mind, which amount to more than mere transitory delirium, and which supervene in the course of, or follow upon, infectious fevers, or specific diseases attended with fever. These psychoses seem to me peculiarly worthy of study, for thereby we are likely to obtain an insight into the pathogenesis of similar disorders of mind which arise without any obvious cause other than a mere deterioration of health. The infection psychoses, as they may for convenience be termed, are rarely seen in public institutions for the insane; in the first place, they are uncommon; in the second, they are mostly of brief duration. They are to be met with more frequently in the psychiatric clinics of university towns on the continent, no doubt because the patients are readily transferred thither from the ordinary medical clinics when they become troublesome.

Among the specific fevers, typhoid yielded up to recent years the largest number of these cases, but of late years influenza has been a potent factor. Friedländer gives 1.5 to 2.5 per cent as the number of cases of typhoid in which psychoses occur. Erysipelas affecting the head is probably the next most frequent cause; thereafter come malaria and pneumonia. Puerperal insanity, which belongs to the category of the infection psychoses, is in a class by itself. These psychoses, while no doubt mainly appearing after the bodily illness has manifested itself, or at its close, may appear in the form of delirium or mania before there is any fever, and are then only ascribable to a toxin, and fairly comparable to a psychosis due to some drug, to a poisonous substance used in an industry, or to ptomaines. Furthermore, the mental disorder does not by any means necessarily go with high temperatures, even when it appears after the bodily illness has become definitely established. This is the first instructive lesson I draw from a study of the infection psychoses; they illustrate (in common with insanity from drug poisoning) the ability of a toxin to cause insanity. A second instructive fact is that there is no difference in the kind of symptoms by which one can distinguish the psychosis caused by one infection or intoxication from that caused by another. The brain reacts in common, limited, well-recognised ways, irrespective of the nature of the provocative disease, it reacts to toxins; from which it appears that different toxins are capable of producing the same effects upon the cerebral cortex.

These psychoses exemplify the most diverse clinical forms; thus, acute delirious mania, mania, melancholia, states resembling closely certain of those deemed characteristic of dementia præcox, others resembling those seen in insanity with epilepsy (e.g., states of agitation, post epileptic stupor), acute confusional conditions, an exalted state resembling that seen in dementia paralytica, the syndrome of Korsâkow—with its preliminary agitation and subsequent disorder of memory and attention power; above all, they take the form of acute hallucinatory insanity. In the post febrile period dementia of varying degree is shown. In short, if we exclude systematized delusional insanity, the above summary includes practically all the forms in which disease of the mind manifests itself. The specific fevers can reproduce them all, so that differential diagnosis from like mental disorders as ordinarily seen is for the time being practically impossible. The only essential difference is that in the symptomatic psychosis the disorder is commonly of shorter duration than in the so-called "endogenous" psychoses, although after typhoid and influenza varying degrees of mental defect may last for years. The above considerations naturally prompt the inquiry as to whether the forms of insanity we are accustomed to meet with, of unknown origin, are due also to toxins, exogenous or endogenous. A third point which is noticeable in connection with the infection psychoses is that one and the same provocative disease (toxin) produces different forms of mental disorder in different persons, which is presumably due to individual peculiarities.

A special reference seems desirable to the pseudo general paralysis which occurs in connection with some of the specific fevers, a point alluded to by Bonhoeffer[20] in his study of the symptomatic psychoses. As far as I am aware the pupillary reflexes are never altered, but the typical mental symptoms are reproduced, and the speech is affected, although not typically, yet in such manner as to cause difficulty in diagnosis. The knee-jerks may be exaggerated. As the pupillary phenomena are not present in every case of true general paralysis it must have been practically impossible to diagnose the simulated from the real disease by the mere symptoms in days prior to the introduction of serological, chemical, and cytological tests in respect of the cerebro-spinal fluid. A further special reference may be made to the occurrence of symptoms indistinguishable from those given as characteristic of the katatonic variety of dementia præcox. There are the stupor, flexibilitas cerea, verbigeration, echolalia, and echopraxia, stereotypy, rhythmical movements, rigidity of attitude, grimacing, mimicking, tics, and negativism; in fact, there is the entire symptom complex of this type of dementia præcox. Bonhoeffer has recently given some good descriptions of this condition following upon typhoid and pneumonia. A condition resembling katatonic stupor has been described[21] as developing in a case of pellagra; the patient apparently had a predisposition to mental disorder, as she had an attack of mania six years previously, before the pellagra showed itself. The infection psychoses furnish instances in which a given symptom complex is produced by more than one morbific agency, and therefore constitute an argument against specificity in causation of the various kinds of insanity. The abnormal constitution of the brain in individuals falling victims to mental disorder would seem to be of more importance than the exciting cause; the *irritabile* more important than the *irritans*.

The study of metabolism in mental disorders is in its infancy; methods hitherto employed are inadequate to deal with the subject. The same is true of chemical methods. The most concordant results are in respect to epilepsy with insanity, dementia paralytica, dementia præcox, and manic depressive insanity. But the changes observed up to the present are not pathognomonic.

That psychical disturbances influence metabolism is but another way of saying that the body is influenced by the mind. It having been demonstrated in a given case of insanity that a disorder of metabolism is present, the question of cause and effect remains to be determined. One of the best instances of parallelism between disorder of mind and disorder of metabolism, and one of the readiest to suggest itself, is the occurrence of glycosuria in conditions of mental agitation, or agitation with depression, such as occur in different kinds of insanity. According to Allers the periods of excitement of general paralytics and epileptics are associated with an excretion of acetone bodies. The origin of these is a matter of speculation. Then there is the phosphaturia connected with states of mental agitation. I fear that in such instances as these it is difficult to get beyond the unsatisfactory position of psychophysical parallelism.

Metabolism in Epilepsy.

The work of Rohde[22] is cited by Allers as particularly exact and critical. He finds in severe cases a disturbance in nitrogen metabolism, there being a retention of nitrogen, which reaches its maximum immediately before the fit. The pre-paroxysmal stage is also marked by the appearance of an increased quantity of ether soluble acids. The significance of this expression is dubious, and it requires explanation. The retention of N would appear to be the characteristic of the fit-free stage, but it is not peculiar to epilepsy, for a similar condition has been described in connection with the katatonic phase of dementia præcox and in dementia paralytica. After the epileptic seizure there is an increased excretion of N, which reaches a maximum at the close of a series of fits, and after the *status* there is a negative balance. Uric and phosphoric acids are also excreted in increased amounts and also lactic acid; the last is probably due to muscular contractions and asphyxia. Guidi,[23] from his researches into the pathogenesis of epilepsy, also describes a profound alteration in nitrogenous metabolism.

Metabolism in Dementia Paralytica.

The study of metabolism in this disease is rendered extremely laborious and uncertain owing to the restlessness of the patients and the difficulty of obtaining 24-hour specimens of the excreta. In 1908 Kauffmann[24] wrote a monograph embracing the study of a few cases, but the value of his laborious work is much diminished by reason of its unsystematic and diffuse nature. He brings out the point of the disturbance of the water balance; the balance is negative, the loss of water partly accounting for the enormous loss of weight in this disease. Other workers, as Allers refer to the great variations in the water balance. There are, further, great variations in weight not dependent upon food intake. The loss of weight is not counterbalanced by subcutaneous infusion of salt solution. The process of heat regulation is also disturbed. For the temporary febrile states which one observes in general paralytics, if the temperature is taken regularly every three or four hours, and for which there is no apparent cause, Kauffmann suggests, by way of explanation, the accumulation of intermediate products of metabolism. The fever thus produced brings about increased oxidation and so becomes extinguished. These febrile states have commonly been explained upon a theory of infection and not upon one of auto-intoxication. In dementia paralytica, and, in fact, in all psychoses leading to dementia, products of degeneration of nervous tissues (*abbau produkte*) are to be found in the glia cells, and cells of

[19] Kosowsky: [illegible] Zeitschrift für Psychiatrie, Band [illegible], 1912.

[20] Bonhoeffer: Die Symptomatischen Psychosen, 1910.

[21] Cole: The Lancet, September 6th, 1913, p. 717.

[22] Rohde: Deutsches Archiv für Klinische Medizin, Band xcv., 1908.

[23] Guidi: Rivista Sperimentale di Freniatria, vol. xxxiv., 1908.

[24] Kauffmann: Beiträge zur Pathologie des Stoffwechsels bei der Psychosen, G. Fischer, 1908.

the adventitia of blood vessels, in considerable, sometimes in enormous, amount. These have commonly been looked upon as of a fatty nature, but on insufficient evidence. It remains to be seen what they really are from a chemical standpoint and, by experiment, what noxious influence they may have.

Recently Allers has published the results of a prolonged research in the metabolism of dementia paralytica, his chief conclusions being that endogenous protein metabolism is increased, as evidenced by the negative nitrogen (and sulphur) balance, with uniform intake of nitrogen. Nevertheless, the metabolic changes are not carried out to their end stages; they are quantitatively greater but qualitatively deficient—incomplete. These definite metabolic changes, occurring at any rate in certain phases of the diseases, are regarded as showing the existence of a general, not merely a cerebro spinal, disorder. Before their significance for dementia paralytica can be estimated control experiments in other organic diseases of the nervous system are necessary, but these, as Allers points out, are as good as non-existent. It is highly significant that considerable metabolic disturbance may be present with but small loss in weight, for in persons prone to mental disorder slight losses in weight frequently go with a definite disturbance of the mental balance.

Metabolism in Dementia Præcox.

The katatonic form has been carefully investigated by Rosenfeld, the four cases he worked with being in a stuporose state; they were upon a fixed diet and fed by tube. The positive result was that *N* was retained in considerable quantity in all cases, even in periods when insufficient food was taken and the body weight sank. The nitrogen he believed to be in the form of available free protein, and for reasons he states. Pighini obtained a like result, but in the chronic phase of the disease (which is characterized by dementia, negativism, tics, and stereotypy), and phosphorus was also excreted in diminished quantity, while excretion of calcium and sulphur was increased. In the acute phase, or with exacerbations, characterized by motor restlessness, impulsiveness, and sensory excitement, the *N* balance was negative, and sulphur and phosphorus (especially neutral sulphur) were excreted in increased quantity, which Pighini ascribes to increased nucleo protein katabolism. In the final, chronic stage, characterized by dementia—instances of which so largely help to fill asylums—the chemical exchange is physiological, as one would expect. In the active phase of this disease, as in dementia paralytica, there are great variations in weight, not wholly dependent upon food intake; the latter may be abundant and absorption good, and yet the patient loses weight. The work of Rosenfeld goes to show that these variations, as in dementia paralytica, are due largely to disturbance in the water balance.

Grafe, in 18 cases of stupor occurring in different forms of mental disorder—such as the katatonic form of dementia præcox, dementia paralytica—found a definite lowering of metabolism, especially in the dementia præcox cases. The production of heat was diminished to 89 per cent below normal. Apart from myxœdema, such an extreme reduction is believed to be very rare. In these cases there was no marked emaciation and no hypotonicity of muscle. And such reduction is, according to Grafe, not found in chronic under nutrition. From the researches of Borstein, Bornstein and Oven, and Grafe it follows that the exchange of energy, as estimated in calories, is very considerably diminished, and below the limit of physiological variation, in some cases of dementia præcox.

Extremely little experimental work has been done in the metabolism of manic depressive insanity.

Allers: Zeitschrift für die gesamte Neurologie und Psychiatrie, Band xvii., Hefte 1 and 2, 1913.

Rosenfeld: Allgemeine Zeitschrift für Psychiatrie, Band lxiii., Hefte 3 and 4.

Pighini: Rivista Sperimentale di Freniatria, vol. xxxii., 1906, and vol. xxxiii., 1907.

Grafe: Deutsches Archiv für Klinische Medizin, vol. cii., Heft 15, 1911; Zeitschrift für Physiologische Chemie, vol. lxv., Heft 21, 1910.

The Dyestuff Industry

According to the daily press, the manufacturers of both cotton and woolen goods and other color-using industries in this country are being put to considerable difficulties in securing a sufficient supply of dyestuffs. One or more of these sensational articles stated that there was a possibility of this famine in dyes forcing textile mills to shut down and throw about 400,000 employees out of work. Aniline dyes are produced principally in the countries in which war now rages, and the chief source of the material used in the United States has been Germany. The interference with Germany in shipping dyes into this country at the outbreak of the war immediately awakened serious apprehensions in the minds of some of those who had a knowledge of our dependence on Germany for coal-tar dyes.

The more recent articles on this subject published in the trade and scientific papers dealing with dyes, textiles and all industries depending in whole or in part upon German coal-tar products, refer to the situation as far less perplexing than the daily press originally seemed to indicate. In an article headed "Contributions of the Chemist to the Industrial Development of the United States—A Record of Achievement," by Bernard C. Hesse, *The Journal of Industrial and Engineering Chemistry*, April, 1915, raises the question: *Is there a shortage?* This question is not answered affirmatively, but Mr. Hesse goes on to show that the present difficulty, for instance, in the textile industry does not lie in the lack of dyes, but that the real cause goes deeper than the dyestuff question, because the mills cannot sell their goods. But, he says, if they could sell their goods in this country or elsewhere, they might buy more dyestuffs than they do.

Mr. William W. Skiddy of the Stamford Manufacturing Company, Stamford, Conn., according to the New York *Times* of April 11th, 1915, says:

> "I think the excitement which has been caused by many of these articles is uncalled for, for the reason that there are dyestuffs in considerable quantities made in the United States. There are some who manufacture anilines in the United States, and there are also large manufacturers of vegetable dyes in this country, such as logwood, fustic, hypernic, etc. These dyes were made for a great many years prior to the knowledge of any aniline colors, and were universally used by the textile manufacturers and others who had to use colors."

About sixty years ago the United States manufactured practically all dyestuffs used in this country, but those colors were of vegetable origin. The dye-wood extract industry was developed here, but our methods were immediately copied by the Europeans, and many factories for making dyestuffs soon sprang up in England, France, Germany, Italy, and Russia, where labor was cheaper than in the United States, and the finished product could be imported for less than it could be made here. Another serious blow to the American dye industry was the rapid development of coal-tar dyes in Germany. Enormous quantities of these colors of almost unlimited varieties are now made in Europe and practically all of them have been introduced and are now in great demand among American color-using concerns. These are at present about 1,200 shades or combinations and they are still increasing.

It is gratifying to learn from various reliable sources that the domestic manufacturers by running full time can satisfy the normal requirements of the color-using concerns in this country. It is understood, of course, that American manufacturers cannot now make a number of the shades which have been recently produced in Germany, nor can it be determined what per cent of the color actually made available for use in this country will be of coal-tar origin. German dyestuffs will continue to come in and the position of the domestic manufacturer of coal-tar dyes may remain unchanged until the tariff laws are modified.

There is a fair possibility, however, that vegetable dyes are coming into their own again. It is claimed that the adjustment of the machinery in dyeing plants for the use of vegetable as against coal-tar dyes is not very great, as is shown by the fact that a number of textile manufacturers use both kinds of dyes, depending upon the material to be colored. Another factor in favor of the possible increased use of the vegetable dye is that the producers of this class of goods are fully equipped and can procure the raw material at the present time under the most favorable circumstances. The woods come chiefly from tropical America, and since the shipment of these woods to Europe is considerably curtailed, they are now offered in the American markets at figures below the normal.

While the use of dyestuffs in general has increased enormously in recent years, that obtained from dye-woods has decreased. From 1860 the quantity and value of dye-woods imported steadily increased until about 1890, when the coal-tar dyes began to come into general use. During the succeeding decades the amounts imported fell abruptly. The total value of dyestuffs (logs and extracts) used is given in the following table:

Year.	Value.	Year.	Value.
1860	$338,186	1890	$1,726,187
1870	1,337,098	1900	862,462
1880	1,808,730	1910	866,577

Since 1910, the annual imports of dye-woods amounted to about $500,000. Among the woods used logwood stands first. It is of West Indian origin and is adapted particularly for coloring leather, and for dyeing textiles it is also considered by some as superior to all artificial dyes. Fustic, which also comes from the West Indies, stands second in importance among the woods used for extracting a dye. It is used principally in dyeing woolen goods a bright yellow color. Young fustic, camwood, barwood, sanders, sappan, and the Brazils come into this country in varying quantities. In addition to these foreign woods, vast quantities of oak bark are used, as well as a long list of other vegetable tissue of minor importance. But this can hardly ever be satisfactory. Not only are most coal-tar dyes cheaper than vegetable dyes, but the variety of shade is far greater.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, MAY 22nd, 1915

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year		$5.00
Scientific American (established 1845)	"	3.00
American Homes and Gardens	"	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

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SCIENTIFIC AMERICAN SUPPLEMENT

VOLUME LXXIX
NUMBER 2066

NEW YORK, MAY 29, 1915

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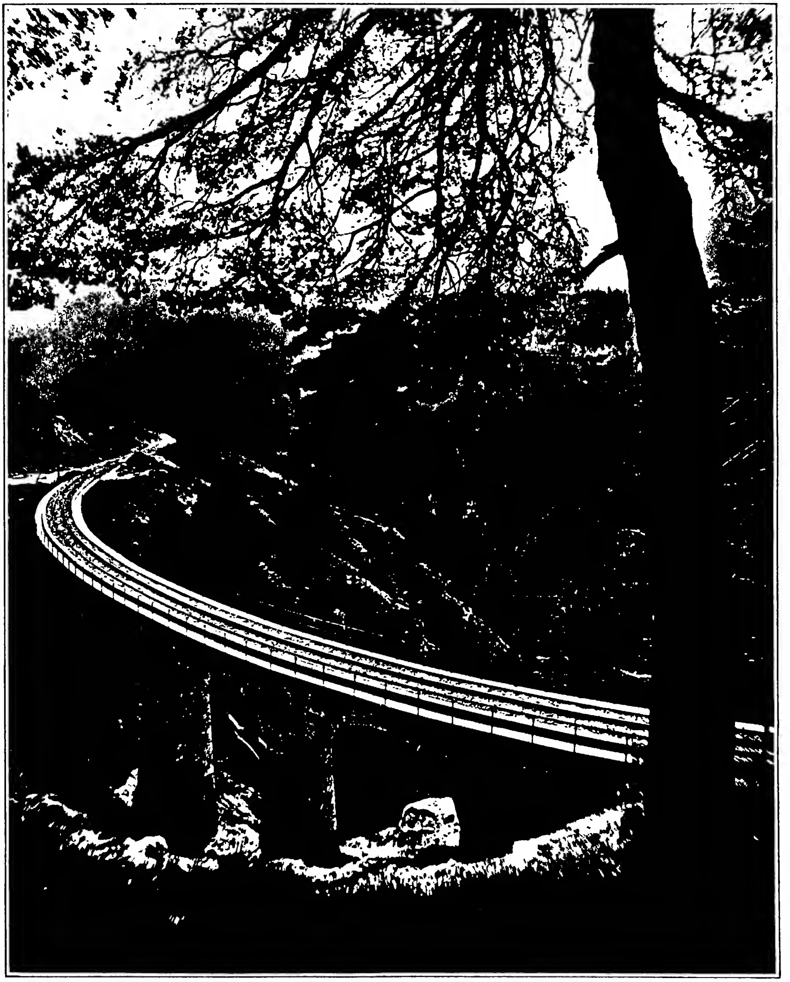

A picturesque view of the line in the high Alps.

THE NEW FURKA PASS RAILWAY IN SWITZERLAND.—[See page 344.]

Developments in Electromagnetism—I*

A Review of Some Important Problems, and the Laboratory Results

By Eugene Bloch, Professor at the Lycée Saint Louis

The domain of electromagnetism is to-day so broad and so complex that in a few pages we cannot hope to show all its frontiers. For the present, therefore, we will limit ourselves to reviewing certain problems which particularly attract our attention, either by the number or the importance of the investigations which they have produced. We will start with the theoretical developments and end with the results gained in the laboratory.[1]

I. THE DYNAMICS OF THE ELECTRON. THE ELECTROMAGNETIC MASS.

The electromagnetic theory of matter and the ether in the perfected form due to H. A. Lorentz is really a theory of electrons. Matter in all its forms is by it considered as made up of complex groups of which an essential element is the negative electron either free or bound to an atom. This element is defined by its charge e (4.5×10^{-10} electrostatic units) and its mass, which is invariably at small velocities ($e/m = 1.76 \times 10^{7}$ electromagnetic units). This result was the logical consequence of a long and brilliant series of discoveries which marked the end of the last and the beginning of the present century (cathode rays, X-rays, gaseous ions, Zeeman effect, radioactivity, etc.).

A fundamental problem of this theory is evidently the study of the motion of an isolated electron and the electromagnetic perturbations which accompany it. This problem gains in interest as experimental demonstration becomes possible. Cathode rays from all sources (rays from Crookes's tubes, from the photoelectric effect, the β rays from radium) are, indeed, fluxes of electrons projected at great velocities from matter. Let us, therefore, review first the important results of the theory which was developed by Heaviside and Searle and later and fundamentally by J. J. Thomson (1881), a theory which has passed through many successive developments.[2]

(1) An electron moving with a uniform velocity, or at least a velocity only slowly variable (quasi-stationary), carries invariably tied to it an electromagnetic field the form of which can be completely deduced from the Maxwell-Lorentz equations. This moving field has been called the "velocity wave."

(2) If the electron suffers an acceleration, a wave is immediately propagated from it having all the characteristics of a luminous wave (transverse vibrations, rectangular electric and magnetic fields). This disturbance has been called an "acceleration wave." At great distances from the electron the latter wave alone exists because its amplitude varies inversely as the distance from the electron and not as the inverse square as does that of the other wave. This shows us the probable origin of luminous radiations and the root of the explanation of the Zeeman effect. Here also we find the explanation of X-rays which are electromagnetic pulses[3] due to the abrupt stoppage of cathode corpuscles at the anticathode and the resulting negative acceleration.

(3) In order to give an electron a quasi-stationary movement there must be communicated to it energy which is stored up in its field as electric and magnetic energy. The necessary calculations for this field are relatively simple where the ratio (β) of the velocity (v) of the particle to the velocity of light (V) is small. They become more complicated where β approaches unity and were first made completely by Max. Abraham[4] in 1903 upon the hypothesis of a rigid, spherical electron carrying a charge uniformly distributed throughout its volume. Then the magnetic energy of the field can always be expressed in the form of kinetic energy, $\frac{mv^2}{2}$. It is quite natural to speak of the coefficient m as the electromagnetic mass of the electrons. This mass may be superposed upon the ordinary mass, at least it does not wholly take its place. This leads to an electromagnetic interpretation of mechanics. In this new mechanics, the mass m does not maintain a constant value m_0 except at very small velocities. For a velocity comparable with that of light (β near 1) the mass becomes a function of β and increases indefinitely as β approaches unity. Further, it is necessary to distinguish between a longitudinal and a transverse mass according to the orientation of the acceleration with regard to the velocity. The transverse mass, detectable only in the experiments with the deviations of the cathode rays, is given according to Max Abraham by the relation

$$\frac{m}{m_0} = \frac{3}{4\beta^2}\left\{\frac{1+\beta^2}{2\beta}\, L\, \frac{1+\beta}{1-\beta} - 1\right\}$$

This formula seemed completely verified by the observations of Kaufmann[5] (1900 and 1903). He measured the variation of the ratio e/m with the velocity for the β rays from radium, utilizing the electric and magnetic deviations of the electrons having velocities reaching ninety-five one-hundredths of the velocity of light.

Since then other formulæ have been proposed in the place of this. Langevin and Bucherer,[6] basing their formula upon the hypothesis of a deformable electron of constant volume, obtained

$$\frac{m}{m_0} = (1 - \beta^2)^{-\frac{1}{3}}$$

Further, as a consequence of the development of the theory of relativity (see Section II of this article), H. A. Lorentz, postulating an electron of constant equatorial diameter, deduced a third formula:

$$\frac{m}{m_0} = (1 - \beta^2)^{-\frac{1}{2}}$$

These new formulæ also appear to fit the experiments of Kaufmann. It became necessary, therefore, to make new experiments more precise than those of Kaufmann in order to choose between the various formulæ. Several attempts to do this have been made.

Bucherer[7] placed a grain of radium fluoride at the center of a condenser formed of two flat disks 8 centimeters in diameter and separated by 0.25 millimeter. This condenser was inclosed in an air-tight cylindrical box, the walls of which carried a photographic film. This was all placed in a uniform magnetic field parallel to the plates and a very perfect vacuum produced. When the condenser is charged, the β rays trace upon the film a line the analysis of which permits the calculation of the variation of e/m with the velocity. In this case the formula of Lorentz is found to fit best, confirming nicely the principle of relativity.

These conclusions have been clenched by yet later experiments. Hupka[8] used the electrons from the photoelectric effect, produced in a very perfect vacuum and accelerated by intense electric fields reaching a strength of 90,000 volts. The knowledge of the velocity v and the ratio e/m was deduced from the magnetic deviation, rendered evident by a fluorescent screen, and the magnitude of the accelerating potential. The maximum velocities obtained were of the order of $v/2$. The formula of Lorentz fits these observations also better than that of Abraham. However, these experiments are less convincing than the preceding one, as Heil noted,[9] since the highest potentials must be known with a precision greater than 1 per cent, an accuracy difficult to obtain.

C. E. Guye and Ratnovsky,[10] desirous of escaping this difficulty, used ordinary cathode rays, produced in a good vacuum, and deviated at the same time both electrically and magnetically so as to get rid of the necessity of measuring the potential used. These results also confirm Lorentz's formula at the expense of Abraham's.

We are led by all these results to look upon an electron as deformable only in the direction of its motion, conformable with the principle of relativity; in this respect they undergo the contraction of Lorentz (see further on). Do all difficulties now disappear? Without considering the objections of a more general nature which are to-day urged against the principle of relativity (see Section II), we must say, no. As H. Poincaré[11] has observed, we cannot comprehend why an electron does not disintegrate spontaneously under the influence of the electric and magnetic forces due to its charge unless there comes into play, in order to maintain equilibrium, other forces from without analogous to pressure. We are led thus to introduce something further than pure electromagnetism as a basis of our new mechanics. We are just as far as ever from comprehending the primordial forces underlying matter.

II. THE PRINCIPLE OF RELATIVITY.

Lorentz has shown that the electromagnetic theory furnishes an explanation of the negative results of the experiments which were expected to demonstrate, either by electrical or optical means, the movement of translation of the earth relative to the supposed stationary ether. These experiments could detect only the effects of the first order with reference to β (quotient of the velocity of translation of the earth, v, relative to the velocity of light, V), while theory shows that the effects should be of the order of β^2 or smaller. This theory then received a rude shock from the celebrated experiment of Michelson (1881) relative to the interference of two rays propagated at right angles to each other and which should show the terms of the second order of β. The negative result was irreconcilable with the theory, the effect observed being less than one one-hundredth of that calculated.[12] We must therefore modify the theory.

The modification necessary was announced almost at the same time by Lorentz and by Fitzgerald. It consisted in supposing that a moving solid body suffers a contraction in the direction of its motion equal to $\beta^2/2$. This is the celebrated hypothesis known as the "contraction of Lorentz." It seems very strange at first sight and instigated the experiments by Lord Rayleigh,[13] and by Brace,[14] who tried to find evidence of this contraction in the double refraction which it should produce. Their results were negative. In order to explain these consequences and place the theory in a more satisfactory form, Lorentz was led to a hypothesis which contained the germ of the theory of relativity.[15] He showed that the electromagnetic equations for bodies in motion could be put in the same form as for bodies at rest by means of what is called the "transformation of Lorentz." This permits the expression of the co-ordinates x, y, z, and the time t for a system in motion as a function of the co-ordinates x_0, y_0, z_0, and t_0 for the system at rest, thus establishing a correspondence between the electric and magnetic fields of the two systems. This group of transformations contains, as a particular case, the hypothesis of contraction, which is found to be of the magnitude $(1-\beta^2)^{1/2}$, in agreement almost to terms of the fourth order with the magnitude originally admitted. It further explains the negative results of Michelson, Rayleigh, and Brace. Through it we understand the negative results of Trouton and Noble in their electrostatic experiment which was expected to indicate the terms of β^2.[16]

The experiments explained by the transformation of Lorentz go only to the terms in β^2. We do not know any at present which go farther, but it is natural to suppose that even taking into account terms of higher orders, we will never be able to get evidence of the motion of translation of the earth with reference to the ether. In other words, we can probably detect only the relative motions of two material systems with reference to each other and not their absolute movement with reference to a supposed stationary ether. This novel hypothesis was announced in its most general form for the first time by Einstein,[17] who named it the principle of relativity. Starting with this simple principle, Einstein modified slightly the transformation of Lorentz, giving to it a physical basis of very great generality and gathering all the conclusions resulting from it into a group of perfectly consistent formulæ.

We will not state here all the physical and philosophical consequences of this theory of relativity. We will note only the absolute character assumed by the two fundamental postulates of this theory: First, the ether is immovable and penetrates matter perfectly; second, the velocity of light is an absolute invariant and rep-

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* Translated from *Revue générale des Sciences pures et appliquées*, Paris, 24th year, No. 8, April 30th, 1913, in the Annual Report of the Smithsonian Institution for 1913.

[1] It will be out of the question, for instance, in this review to consider the recent researches on the larger ions, X-rays, radioactivity, vacuum tubes, and the phenomena connected with them (positive rays, etc.), or atmospheric electricity.

[2] See the references cited further on.

[3] We have not sufficient space to describe the curious theory of Bragg, according to which the X-rays and the γ rays of radium are uncharged particles of matter. Moreover, this theory appears to be contradicted by the recent beautiful experiments of Laue and his pupils upon the diffraction of X rays by crystals. (Bragg, *Phil. Mag.*, October, 1907; *Chem. News*, vol. 97, p. 162, 1908; *Radium*, p. 213, 1908. See also articles by Brunet in this *Revue* for February 15th, 1913.)

[4] See *Ions, electrons and corpuscles*, vol. 1.

[5] See *Ions, electrons and corpuscles*, vol. 1.

[6] Langevin, *Revue générale des Sciences*, p. 267, 1905.

[7] Bucherer, *Physik. Zeitschrift*, vol. 9, p. 755, 1908; *Annalen der Physik*, vol. 28, p. 513, 1909.

[8] Hupka, *Verh. der Deutsch. Phys. Gesellsch.*, vol. 11, p. 249, 1909; *Annalen der Physik*, 1910.

[9] Heil, *Annalen der Physik*, vol. 31, p. 519, 1910.

[10] Guye and Ratnovsky, *Comptes Rendus*, CL. p. 326, 1910.

[11] H. Poincaré, *Rendiconti del Circolo Math. di Palermo*, vol. 21, p. 129, 1906.

[12] The original experiment was made by Michelson and Morley in 1887 and repeated most recently by Morley and Miller, *Phil. Mag.*, vol. 9, p. 680, 1905.

[13] Rayleigh, *Phil. Mag.*, vol. 4, p. 678, 1902.

[14] Brace, *Phil. Mag.*, vol. 7, p. 317, 1904.

[15] See the admirable book by Lorentz, entitled "The Theory of Electrons," and published by Teubner in Leipzig, 1909.

[16] Trouton and Noble, *Phil. Trans.*, vol. 202, p. 165, 1903. See also Langevin, *Comptes Rendus*, vol. 140, p. 1171, 1905.

[17] Einstein, *Annalen der Physik*, vol. 17, p. 891, 1905.

resents a superior limit which no other velocity can exceed. (whether for matter in motion or the propagation of waves). The theory has been further developed (principally by Germans) by Einstein (1905-1912), Minkowski (1905-1908), Planck (1907-1908), Born (1909), Sommerfeld (1910), Laue (1911), etc. The various points of view which these physicists have adopted are too numerous to be given here in detail; some have tried to put the transformations of Lorentz into more geometrical and comprehensive form (Minkowski); others have deduced the kinetic consequences of the principle, either for a moving point (composition of velocities according to Sommerfeld) or for a solid body in rotation (Born, Laue, etc.). Difficulties and complications quickly arise as soon as the motion of uniform translation originally supposed is departed from and these difficulties have not yet been overcome. The total absence of any experimental basis or confirmation of these later developments deters us from further discussion. We will stop a moment only on one of the most paradoxical consequences of the principle of relativity which will bring out the difficulties which the theory encounters and rebut the absolutism of the principles which it uses as bases of the physical sciences. At the start Einstein[18] showed that if the energy of a system increases by the amount E, *the principle of relativity requires that its mass increases at the same time by* E/V^2. Only on this condition can the principle of the conservation of the movement of the center of gravity as well as the new system of mechanics be maintained. Accordingly, mass and energy are not really distinct; the principle of the conservation of mass is inseparable from the principle of conservation of energy. This result, however strange, is nevertheless consistent in itself.

Einstein himself, basing his deductions on this consequence, tried to bring back to the principle of relativity the absolute value which had been attributed to it since 1905.[19] He has tried to include in the electromagnetic synthesis of the universe the phenomenon of gravity, hitherto so rebellious against all our efforts at explanation. He noted that a uniform gravitational field of constant acceleration, γ, is equivalent to a medium free from gravitation in which the reference axes are supposed acting with a uniform acceleration $-\gamma$. Next we must generalize the principle of relativity and pass from the case considered until now of a uniform velocity of translation to that of a uniform acceleration. In the earlier case we were led to attribute to energy a mass $m = E/V^2$; now, if we wish to preserve the principle in its entirety we must attribute to the same energy the weight $m\gamma$. As a particular case, radiant energy, light, must have weight; a beam of light must then be deviated by the masses close to which it may pass. Einstein's calculation showed, for example, that the angular distance between a star and the center of the sun must be decreased by about one second when the star appears close to the sun. The measurement could be attempted at a total eclipse of the sun.

There is no need of calling attention to the strangeness of these conclusions. The important thing from a philosophical point of view is that we are obliged to give up the absolute invariability of the velocity of light, V, considered at the start as an unassailable axiom. This invariability is only true in a system where the gravitational potential Φ remains constant. For variable potentials the velocity of light must vary according to the formula, $V = V_0 (1 + \Phi/V^2)$. So it is only in the case of uniform motion of translation that the transformation of Lorentz represents the phenomena of a system in movement. In the more general case the group of transformations is more complicated and as yet undetermined; the equations to be substituted for those of the classic electromagnetism are also undetermined.

This new point of view of Einstein has at least one incontestable utility: it makes us realize that the postulates which were at the basis of the earlier principle of relativity (the invariability of V, etc.) are perhaps only approximate affirmations, susceptible of modification, and not first truths. It has led us from metaphysics to physics. And since the discussion became opened anew concerning the foundations proposed by Einstein we will not be surprised to find that Max Abraham, adopting this new conception of mass and weight, has developed a new theory of gravitation, different in many respects from that of Einstein. Abraham[20] renounces the generalization of the principle of relativity in the case of acceleration. Then considering that as a whole the principle of relativity has failed, he keeps the Lorentz transformation only for very small changes in the variables. Considerable discussion has passed between him and Einstein, but we will not follow the details.[21]

Admitting that these theories will have a lasting effect upon science, in the future new experiments will be required and a more powerful theoretical effort than that of the past. We will close our exposition of this question by citing the opinions of several skeptical physicists who, from the beginning, have found the postulates upon which the theory of relativity rests too absolute and to whose voices we are now beginning to listen.

The ether in the principle of relativity has been emptied little by little of all its physical properties; it is represented now only by a system of mathematical equations, those of Maxwell-Lorentz, and a number, the velocity of light. It remains as the vehicle of radiant energy without our questioning how. Ritz,[22] following to the logical conclusions such notions, proposes to renounce wholly the hypothesis of an ether and to return to a theory very close to the old one of emission. According to him, we need not speak of electric and magnetic fields, but only of electric charges acting upon each other. We thus return to action at a distance but taking into account the finite velocity with which such action takes place. Consequently, it is necessary to throw away the partial differential equations of the electric field and replace them with integrals (retarded potentials). There is thus introduced an irreversibility of which the former equations could not take account. Mass at great velocities will remain constant, but the force will vary. We thus arrive at another system of mechanics. Against these new conceptions, the development of which was unfortunately interrupted by the death of the author, there are grave objections which have so far kept the majority of theorists from adopting them, although they are perfectly consistent among themselves.

Brillouin,[23] on the other hand, makes the ether more substantial than has been customary. There must be, according to him, a drastic revision of the hypotheses relative to it. For example, its absolute immobility, perfect permeability, homogenity, isotropy, and the invariability of the velocity of light. Those upholding the principle of relativity have themselves commenced to attack the last postulate, as we have just seen. Now it will be the turn of the other properties. We may come, through the increasing acuteness of our powers of analysis, to admit, to a closer degree of approximation, that the ether, at least slightly, is similar to ordinary matter, that it may propagate a disturbance with a velocity greater than that of light, that it does not remain perfectly stationary when matter traverses it, etc. New experiments must be added to the purely electro-optic ones of Michelson, Rayleigh, Brace, and Troughton before we will be able to build these theories.

(*To be continued.*)

[18] Einstein, l. c. and *Annalen der Physik*, vol. 20, p. 627, 1906; vol. 23, p. 378, 1907, etc.

[19] Einstein, *Jahrbuch der Rad. und Electronik*, vol. 4, p. 4; *Annalen der Physik*, vol. 35, p. 898, 1911, etc.

[20] Max Abraham, *Phys. Zeitschr.*, vol. 13, No. 1, 1912; *Annalen der Physik*, vol. 38, p. 1,056, vol. 39, p. 444, 1912; *Nuovo Cimento*, January, 1913.

[21] Einstein, *Annalen der Physik*, vol. 38, pp. 355 and 1,059, 1912; vol. 39, p. 704, 1912.

[22] Ritz, *Annales de chimie et de physique*, vol. 13, p. 145, 1908.

[23] Brillouin, *Scientia*, vol. 13, p. 10, 1913. See the *Revue générale des Sciences*, March 30th, 1913, p. 214.

Phenol for Coal Analysis

Broadly speaking, coal is analysed and tested for practical purposes in two ways. In one case the elementary constitutents of the coal—carbon, hydrogen, oxygen, and nitrogen—are determined separately by ultimate analysis, in addition to moisture and ash; the data obtained are useful for calculating the total heat content or calorific value of the coal. Alternatively the volatile matter is separated by distillation from the fixed carbon; the ratio of the two, designated the fuel ratio, in a certain measure indicates how much of the coal will be available as coke and how much in volatile and condensable products. Neither of the two methods gives any clue as to the real constituents of the coal, which is more or less a complex of hydro-carbons. But as it is quite understood that coal changes in the course of time, and that the period during which a coal may be stored without serious loss, its spontaneous combustion, smoke formation, and the behavior of coal in general depends upon the nature of the original constituents, other methods have been tried. These latter methods are still in the research stage. The general idea of the research is to separate the different constituents so far as possible by the use of solvents. Already at the time of the first London Exhibition of 1851, Smythe tried benzine, chloroform, alcohol, acetone, ethyl ether, and petroleum ether, for this purpose on a lignite from the Rhine; Remsch, in 1885, used alkaline solvents. H. B. Baker, in 1901, and A. Wahl, and several others after him applied pyridin with better results than previously obtained. A. H. Clark and R. V. Wheeler[1] found that pyridin roughly separated the coal into an extract containing mainly the resinous substances—i. e., the degradation products of the resins and gums in the plants which had been transformed into coal, and an insoluble residue consisting of the degradation products of the cellulose; by further treating the pyridin extract with chloroform they obtained an extract almost entirely resinous in character. They also observed that the destructive distillation of coal gave, below 750 deg. Cent., chiefly "paraffin-yielding" constituents derived from the resinous compounds, and above that temperature "hydrogen-yielding" compounds (mainly hydrogen and oxides of carbon). Thus the extraction with pyridin and chloroform effected somewhat the same separation of the coal constituents as the destructive distillation, and coal would appear to consist of two types of constituents, differing as to the ease of their decomposition.

Other organic solvents were tried in 1912 by Frazer and Hoffman (Technical Paper 5 of the United States Bureau of Mines). They found phenol to be a suitable solvent, and phenol in particular has been experimented with by S. W. Parr and H. F. Hadley in the Engineering Experiment Station of the University of Illinois (see Bulletin 76 of that station). Parr and Hadley have studied a great many organic solvents as to their effectiveness as solvents for coal. In the first rank they put phenol [C_6H_5OH, chemically the alcohol of benzine; it has the character of an acid, and is commonly styled carbolic acid]. The several cresols, aniline and methyl aniline, otherwise efficient, decomposed during the extraction. Pyridin came next in order, but it appeared to introduce some nitrogen into the extract, a fact already noticed by others; acetone, benzine, carbon disulphide, and turpentine gave only small amounts of extract. When the extraction in the hot by means of phenol was continued too long, above 20 hours, a little phenol or some decomposition product of it remained.

Fifteen different coals, mostly from various mines in the State of Illinois, have been treated with phenol, generally in samples of about 5 grammes, ranging in ash content from 3 to 13.5 per cent. In all cases the extract and the residue together approximately made up 100 per cent, again showing that the continued extraction did not lead to any loss or gain of substance. The proportions of extract to residue varied greatly in different cases, a lignite from Wyoming yielding only 0.6 gramme of extract, a Pocahontas coal from Western Virginia only 0.09 gramme; the average weight of extract was about 1.5 gramme, the rest being insoluble residue. The extract had in most cases a sufficiently definite melting-point and decomposition temperature, and seemed to be the vital constituent concerned in the coking. Both the extract and the residue, especially the latter, as well as the coal itself, readily absorbed oxygen, and the oxygen seemed to be chemically bound. In this respect Parr and Hadley differ from Clark and Wheeler, who assumed that the oxygen formed more or less loose additional complexes, not of definite compositions, with the constituents of the coal. The coking property of the extract was decidedly impaired by the absorption of oxygen.

These are the chief results. We will give a few particulars of the experiments, which appear to have been conducted with care and forethought. Owing to the importance of avoiding oxidation, the continuous extraction, at 180 deg. Cent., was generally effected in an atmosphere of carbon dioxide. At higher temperatures, more extract and less residue was obtained than at 180 deg. Cent. In order to free the product from the solvent, phenol, distillation was carried on at reduced pressure. The cooled extract softened when heated above 300 degrees, without at first becoming sticky; at higher temperature it swelled to three or four times its volume, gave off volatile matter, and left a very friable, shiny mass; not heated above 350 degrees, it became brittle again on cooling. The heated residue also yielded volatile matter, and a very poor, non-caking kind of coke. When the extract and the residue were mixed again in the original proportions, a proper coke could be obtained. A great many coking (destructive distillation) experiments were made, and the photographs of the products are interesting. Both the residue and the extract were hygroscopic, the residue particularly. The ultimate analyses of the original coal, the extract, and the residue differed little as to the proportions of the main elements, while the pyridin extracts seem to be less rich in oxygen than the coal itself. Slow or rapid oxidation, at ordinary or higher temperature, decreased the solubility of the coal in phenol; the residue could be exposed to 105 deg. Cent. without altering it noticeably, because the coking property depends mainly on the extract. The destructive distillation of the three substances—coal, extract, residue—gave less ethylene and ethane and similar compounds, but more carbon dioxide and carbon monoxide when the materials had previously been oxidized than when not. This is the reason why Parr and Hadley assume that the oxygen enters into chemical combination with both residue and extract, and is not merely absorbed or adsorbed.

[1] Transactions of the Chemical Society, 1913, pages 1704; Engineering, vol. xcvi., page 466.

European Aeronautical Laboratories—II*

Their Organization, Equipment, and Method of Investigation

By A. F. Zahm, Ph.D.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2055, Page 330, May 22, 1915

FRENCH AERONAUTICAL LABORATORIES.

The Laboratoire Aerodynamique Eiffel consists of a single building with offices, a wind tunnel and various appurtenances, there being no workshops in the establishment. The wind-tunnel room measures, in round numbers, 40 by 100 feet, by 30 feet high; the three office rooms and garden cover about half as much additional space. Two wind-tunnels, a large and a small one, placed side by side, occupy the center of the room. They are placed well above the floor, to admit of a more nearly symmetrical flow of air. Considerable furniture shelves, drawers, etc.—are placed about the walls; but the body of the room is kept somewhat free of obstructions to secure a less disturbed circulation.

Each tunnel comprises three main parts: the short bell-mouth intake, the model chamber, the long bell-mouth exit. The air from the room traverses the intake through honey-combs placed at either end of the bell-like form; then passes at its maximum speed in uniform rectilinear current across the model chamber; then flows in gently expanding stream and with diminishing speed onward to the larger end of the exit, where it encounters the fan which drives it with replenished energy into the open room. The model chamber is thus seen to be an enlargement of the tunnel proper, spacious enough to accommodate observers, and so sealed from the surrounding room as to have the same barometric pressure as the inflowing current at its narrowest section.

This type of tunnel, adopted by Eiffel after mature experience, has been patented by him as having features of considerable value. He prizes particularly the vacuum chamber for the observers, and for the freer flow of air about the models, uninfluenced by constraining walls. He also prizes the expanding exit, or "diffusor," for slowing the air as it approaches the fan and exhausts into the room, thus realizing great economy of power in maintaining the circulation. It is doubtful, however, whether any of the main features of Eiffel's tunnel are patentable in America. The bell-mouth entrance and exit have been known here many years. The vacuum chamber was employed by Mr. Mattullath and myself in our wind-tunnel constructed in 1901; was disclosed to many others then; and shortly thereafter was described in public prints.

The true function of the "diffusor," or expanding exit, seems to be to prevent turbulence, and thus to promote economy of flow, rather than to increase the pressure of the stream before it reaches the fan, as taught by Eiffel. In other words, the economy of circulation can be achieved by placing the screw at a narrower part of the exit cone, if the pitch of the blades be properly adapted to the stream at that section. But Eiffel's present arrangement presents structural advantages.

The circulation in the large tunnel is maintained by a Rateau screw suction ventilator with helicoidal blades. The screw is driven by a 50-horse-power electric motor, which is found sufficient to maintain a constant flow at any desired speed up to 32 meters per second, or say up to 70 miles per hour. This is a notable result, since the air stream at its swiftest section measures two meters in diameter.

The air velocity in Eiffel's tunnel seems to be satisfactory while used for engineering studies rather than for exact researches in physics. The velocity at all points of a cross-section is uniform in magnitude to within two per cent, and varies but little in direction. A fine silk thread, however, moored in the current, plays a trifle to and fro in both the horizontal and the vertical direction. The current velocity also fluctuates in time, say 1 to 2 per cent.

This velocity is determined, as in the English and other laboratories, from the pressure difference between the vacuum chamber and the large room enclosing the tunnel. This pressure difference is measured with a Shultze manometer, or inclined tube containing alcohol and provided with a graduated scale. In ordinary practice the end of the alcohol column plays several per cent above and below a mean reading, but can easily be located on the scale to within 4 per cent by a capable observer. This means that the velocity can be determined truly to within 2 per cent.

For convenience, in the determination of the wind effect on the various kinds of models, Eiffel places his measuring instruments on a platform, or bridge, spanning the vacuum room, and supported on either side by wheels resting on iron rails secured to the walls, so as to be moved aside when desired. Sometimes also the models are supported on a frame which can be wheeled along the floor. Thus apparatus can be adjusted outside the tunnel, quickly run into place, and again removed without dismantling. This is a unique advantage of Eiffel's arrangement. The main apparatus so employed are the aerodynamic balances, the propeller tester, and the instruments respectively for finding the distribution of pressure and the magnitude and line of action of the total wind force.

Of the *two balances* the simple bell-crank one for the precise measurement of smaller forces has been sufficiently explained as to principle in describing the English laboratory. The large aerodynamic balance, invented by Eiffel himself for determining the lift and drift of the whole wind force, and its line of action, is elaborate in theory, structure, and pratical operation, and is well explained in Eiffel's book, "The Resistance of the Air and Aviation." It is not sensitive enough for measuring the smaller forces on inclined planes and on small models.

The propeller tester is elegantly simple in design and operation. A vertical electric motor, mounted on the bridge above the tunnel, and having its shaft extended down through a wind shield to the center of the air stream, there engages, through bevel gearing, with the horizontal shaft of the model propeller. The shafting of the armature and the propeller are encased in a sheathing which also contains the bearings, and transmits the propeller thrust and torque to the base of the motor. The motor, in turn, is so mounted on pivots and hydraulic gauges as to measure the thrust and torque without material displacement. At the same time the motor speed is indicated by a tachometer attached to the upper end of the armature shaft. The wattmeter method, however, has lately replaced the direct method of measuring propeller torque.

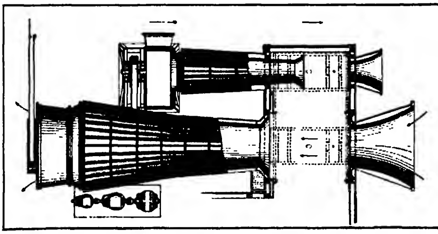
The apparatus for measuring the distribution of air pressure over the surface of models has long been used by others, and in principle is like that employed in the English laboratory, and hitherto described in this report. The instrument for finding directly the line of the resultant air force, or "center of pressure," on a model surface is also an old contrivance, and need not be explained here. It is fully described in Eiffel's book.[4]

The Institute Aerotechnique de l'Université de Paris is described in sufficient detail as to its material plant and operation in its prospectus, and in the following article published in the *Engineering Magazine* for October, 1911:

"The area of the site occupied is about 18 acres. The buildings comprise a central hall, surrounded on three sides by workshops, stores, laboratories, and a power house. In the central hall will be installed experimental apparatus devoted to the study of aerial phenomenal which will include a large fan, 6 feet 6 inches in diameter, and an aerodynamic balance, whereby the pressure of a jet of air on surfaces of various shapes will be determined. There will also be an air chamber supplied by another fan wherein it will be possible to measure the strength, the center of pressure, the components, and the resultant of the reaction of a current of air at any speed up to 65 feet per second. A tunnel similar to that used by Colonel Renard will also be erected for studying the stability of models. An arrangement for measuring the friction of air on surfaces of various natures when the air is moving at all velocities, an electric dynamometer for measuring the torque of propellers fixed in position, apparatus for studying helicopter screws, and a test bench for trials on the putput, endurance, and fuel consumption of aeronautical motors will also be installed. A closed chamber is to be erected, wherein the resistance of helical screws at speeds far in excess of those normally arranged for, and almost at the rupturing speed, will be investigated.

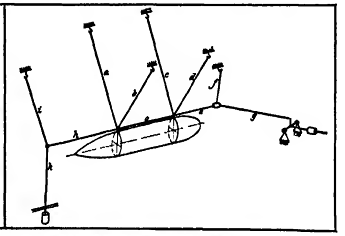
"In the chemical laboratory the study of light gases, suitable for balloon work, will be carried on, and questions relating to their manufacture, purification, properties, etc., will be investigated. The chemical features of various envelope materials, the changes which occur in them under the influence of heat, light, and humidity, the properties and features of the various varnishes applied to render the material airtight and to preserve it, and similar subjects will also be studied. In the physical laboratory the instruments used in aeronautical work, the accuracy of their indications, their reliability and the modifications which are called for in their design to meet aeronautical conditions, will be investigated, while the densities and coefficients of expansion of light gases, and the best means of storing and transporting them will also receive attention.

"A photographer's department has been provided next to the physical laboratory. In the workshops it will be possible to manufacture and repair all the experimental



Plan of the Eiffel aerodynamic laboratory.

The large and small wind tunnels are shown side by side. Their diameter at the experiment room are 2 and 1 meter, respectively.

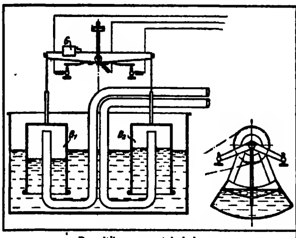


Prandtl's suspension for measuring head resistance.

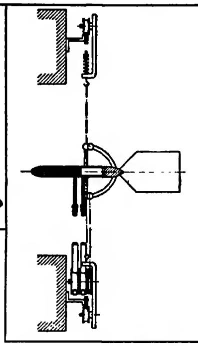
The model is suspended by fine wires and the tension of the mooring wire is measured by sliding weights in adjoining room.

* Smithsonian Miscellaneous Collections, vol. 62, No. 3.

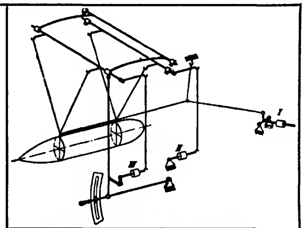
[4] It may be noted, however, that Eiffel's and the English method of allowing a model to rotate about a vertical axis by supporting it on a step bearing is not very delicate, even when a jewel step is used. A more accurate way is to suspend the body from a wire, or float it on a liquid. The writer, in 1901, discarded the jewel pivot and supported his models on a fine steel wire, an oil damper being provided to deaden oscillations. With a float no damper is needed.



Prandtl's monometric balance.



Prandtl's pressure-tube anemometer.



Prandtl's suspension for measuring side force.

appliances required by the institution. A part of one wing is reserved for the installation of machines designed specially to test the materials employed in the construction of aircraft. In the power house, situated at the west end of the building, are two vertical compound steam engines coupled directly to dynamos supplying power and light to the entire institute.

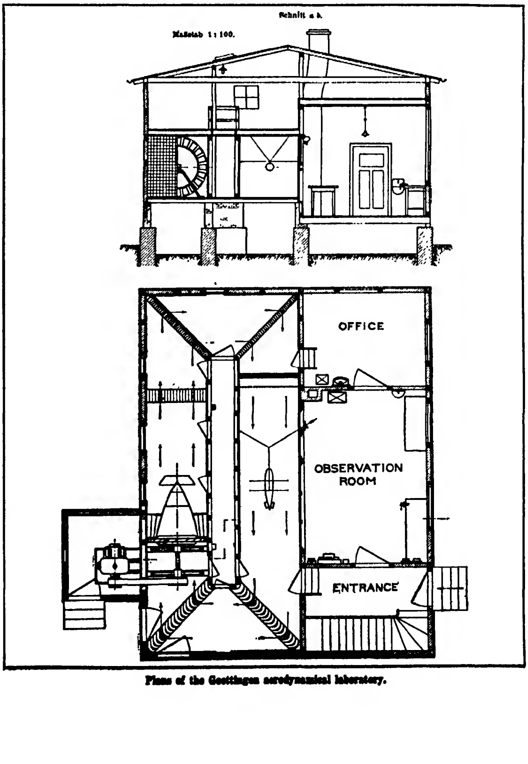
"One of the most interesting features of the institute is the provision made for certain large-scale experiments with planes and propellers. To this end a long, narrow strip of ground is laid out with a normal gauge railway about seven eighths of a mile in length. The rails are laid on oak sleepers, and are bonded in pairs by the aluminothermic process. The line is level over its entire length, with the exception of an incline at each end. At the starting point the line for a length of about 235 feet is given a slope of 1 to 100 to facilitate the starting of the vehicles. At the terminus a slope of half this amount, but extending over about 490 feet, is provided to facilitate the arrest and return of the carriage. On each side of the line and extending along its full length is laid an electrical conductor, whereby current is fed to the motor of the carriage. The return circuit is made by way of the rails. For the last 300 feet or so of the track an additional pair of rails is laid down alongside the running rails. On these additional rails, slippers carried by the vehicle bear so that over this distance, or at least a portion of it, the carriage skates instead of rolling. This facilitates stopping, and in addition furnishes a safety device in case of emergency.

"It is intended ultimately to have four electric carriages to work on the line described above. One has already been constructed, and has been used for a number of experiments. The employment of four carriages has been adopted in view of the fact that each series of experiments requires a different equipment of the carriage and different registering apparatus. If only one were used the time lost in dismantling and remounting it with each series of experiments would be very considerable. It is essential also that each vehicle should be specially designed to meet the conditions of the particular class of experiment for which it is intended. According to present intentions the first carriage will be used to measure the horizontal and vertical components and the resultant of the air pressure on surfaces of sustentation, whether plane or curved, simple or compound. The determination of the direction of the resultant, the center of pressure, its displacement when the angle of incidence is changed and the 'angle of attack' will also be undertaken with this carriage. The second and third vehicles are intended for experiments on propellers or tractors, one being used for the large screws employed for dirigible balloons and the other for the smaller aeroplane screws. The tractive effort, the power absorbed and the mechanical efficiency of each type of propeller will be determined at all speeds. A further important subject of study with these two carriages will be the effect of the translational motion on the output and efficiency of the propellers. A comparison will be instituted between the efficiency, etc., of a propeller when rotating on a fixed axis and when moving with the same speed of rotation, but with various different speeds of translation. The fourth carriage will be specially equipped for measuring the resistance or 'drift' of the various parts of a flying machine.

"The weight of the first carriage is about 3¾ tons, excluding the motor, and a little less than 5 tons with the motor. The body of the carriage is built up of steel plates stiffened with angle irons and measures 20 feet in length and 6 feet 6 inches between the longitudinal members of the frame. Current is supplied to the motor by means of two pairs of sliding contacts carried in the side of the truck. The movement of the carriage is controlled from a lookout-post commanding the whole line.

"All the carriages will be furnished with appropriate measuring instruments. A chronograph will register the number of revolutions of the wheels in a given time, from which the speed will be deduced. In addition there will be a direct speed recorder registering the value of ds/dt at each instant of the travel. A recording watt meter will register the power furnished to the motor either on a time or a distance basis. One or more recording dynamometers will also be carried whereby the particular data being determined will be measured. The efficiency of the whole plant at all speeds, the fractional resistance of the driving and recording gear, the resistance to rolling of the carriage and the air resistance of its elements, will all be determined once for all, so that the power actually absorbed by the surfaces or screws under test may be readily determinable."

Full-scale measurements.—We saw a full-scale Blériot monoplane mounted on one of the electric carriages in such manner that its lift, drift and moment, or center of pressure, could be determined at one time, as it speeds across the field. The speed through the air is measured by means of a pressure-tube anemometer whose pressure collector is a Venturi tube, and has to be calibrated, since its readings are larger than those of a standard instrument such as used by Eiffel, Prandtl and others. The relative importance of such large scale experiments as compared with model tests, or full scale flights with instruments mounted on the aeroplane, has yet to be determined.



Plans of the Goettingen aerodynamical laboratory.

If of new type, the full-scale machine may be tested more safely on a car. The measurements of lift here are said to be in error about 5 per cent; the drift measurements are much less accurate.

A roundhouse, which measures 120 feet in diameter, shelters a whirling table, the extremity of whose whirling arm describes a circle 300 feet in circumference, and carries the models subject to aerodynamic study. This can be used in any weather, while the electric road can be used only at special times, and most effectively only during fair and calm weather. The whirling table, however, does not seem to be so popular in the leading aerotechnical laboratories as the wind-tunnel and large field track. It is not an indispensable part of an aeronautical laboratory, except where studies in circular motion are to be made.

Ancillary buildings have been erected on the grounds near the main laboratory, one for the director immediately in charge, another for the caretaker, who is also a workman assisting in the experiments.

The reports of the investigations are published in the *Bulletin de l'Institut Aerotechnique de l'Université de Paris*. The annual issues for 1912 and 1913 are in the Smithsonian library.

Other French aeronautical laboratories, operating on a smaller scale, are worth mentioning, though unvisited by me for want of time.

The military establishment at Chalais-Meudon, in charge of the Engineer Corps, and under direction of Commandant Dorand, resembles the English Royal Air Craft Factory, in developing experimental air craft and making full scale tests; but it does not manufacture air craft on such a large scale, and does not compete with commercial firms in building for the government, but rather stimulates and helps them to do their best work.

The Conservatoire National des Arts et Metiers, corresponding to our Bureau of Standards, does some aeronautical work in calibrating instruments, testing materials and motors, and furnishes a "mouline Renard" —a standardized revolving bar with paddles at either end—for attachment to a motor to determine its power at various speeds of rotation.

By the use of automobiles on a smooth road Chauviere has tested screw propellers mounted above the vehicle and advancing at natural working speed, and the Duc de Guiche has measured the lift, drift and pressure distribution on aerofoils of considerable size. The accuracy of the automobile method has, however, still to be proved satisfactory. The Chauviere propeller experiments are now made at St. Cyr Institut; but the researches of the Duc de Guiche still continue, and are reviewed from time to time in aeronautical literature The earlier reports comprise two volumes published by Hachette, Paris.

GERMAN AERONAUTICAL LABORATORIES.

The Göttingen aerodynamical laboratory, apart from the constructional and executive departments, is a one-story brick building, in size about 30 by 40 feet, comprising a wind-tunnel and two rooms, one for desk work, the other for instrumental observations. It stands alone, in a remote little meadow on the outskirts of the city, about 15 minutes walk from Prof. Prandtl's university headquarters. It is very cheaply constructed, lighted by electricity, and heated by a little stove in one office.

The wind-tunnel consists of a continuous closed channel, two meters square in cross-section, running round the four walls of the main room. Through this tunnel the air is forced in a steady closed circulation by a screw ventilator two meters in diameter, belt driven from a 30 horse-power electric motor placed in a little off room. As the blast from the blower is too fast along the tunnel walls, it is accelerated at the center of the stream by use of sheet metal fixtures placed in it near the screw, which also help to eliminate whirls. The air stream next passes through a honeycomb (Fig. 1), made of 400 equal sheet metal cells, each about 4 inches square and 20 long, the sheet metal being in two thicknesses, or two-ply, so that either cell can be constricted at will by spreading the cell wall inwardly. Actually, many of the cell walls were so constricted. In fact, the honeycomb looked badly distorted as if much time had been spent in adjusting the cells so that each should deliver the same amount of air. The adjustment once made assures, we were told, an air stream uniform in velocity at all points of a cross-section and at all speeds. One would think that a considerable change of speed would require a new adjustment of the cells to maintain uniformity. Emerging from the first honeycomb, the air passes through vertical sheet metal guide blades, each a double sheet and of turbine blade form, which turn the stream 90 degrees, without eddies; thence through similar blades giving 90 degrees more turn; thence through a much finer honeycomb to remove minor eddies. This last comb, placed just before the test part of the tunnel where the models are inserted, is made of sheet metal strips 10 centimeters wide reaching from floor to ceiling of the tunnel, and held in position by their mutual pressure, comprising among them 90,000 cells. The stream of air issuing from the last honeycomb is said to be uniform, and has a speed ranging up to 10 meters per second.

The measuring instruments employed are numerous; but as several of them resemble the ones already described, they need not be noticed. One favorite method used by Prandtl to measure the resistance of a model, say of balloon form, is to suspend it in the current by fine wires, and hold it against stream by horizontal mooring wire whose tension is measured in the adjoining room by means of a bell-crank and sliding weight. Very accurate measurements can be made without the mooring wires, if the weight and displacement of the model along stream be observed, as in my experiments of 1902. This method, as extended by Mr. Mattullath, has been adopted at Göttingen to measure the resistance of hulls, etc., held obliquely to the current. Prandtl's differential pressure gauge, consisting of inverted cups suspended from opposite arms of a balance, and dipping into a liquid, is like the one devised and used by me early in 1902, and found capable of measuring differential pressures truly to one millionth of an atmosphere, or less. This gauge was described in the *Physical Review* for December, 1903, half a decade before Prandtl's experiments.

The pressure distribution over model screw propellors having perforated hollow blades was measured by transmission through a hollow shaft to a pressure gauge. The screws were made of copper electrically deposited on wax models, and were then emptied of the wax by heating. To show the direction of air flow past the blades, sulphureted hydrogen was allowed to exude from perforations in their surfaces, and thus to stain them. The staining streaks extend fore and aft and very slightly outward radially along the screw blades.

The results of the experiments in the Göttingen laboratory have been published in various German periodicals, and in part translated and republished in *Engineering*, London, for 1911 and 1912, all of which are on file in the Smithsonian library. Particularly interesting are Prandtl's determination of pressure distribution on models of balloon hulls designed in accordance with hydrodynamic theory; also his measurements of the resultant wind force on oblique hulls and wing forms by the method devised and used by H. Mattullath in 1909; also the resistance of wires and ropes, etc. Prandtl found in fair shapes a large difference between total resistance and the pressural resistance, and ascribed the difference to skin-friction; but this he did not measure directly.

The Deutsche Versuchsanstalt für Luftfahrt zu Adlershof comprises one main building used for offices and full-scale aeroplane testing; one used for construction; and five small houses each containing an engine testing apparatus. In addition to this plant, it is intended to fly full-scale machines with measuring instruments, and to mount large apparatus on an aerodynamic car pushed by a locomotive on a railway.

The laboratory of the main building is a large square room with a tower in its center 100 feet high, on top of which wind observations may be made, and inside of which suspension cords run down to support an aeroplane just above the floor, to determine its moment of inertia. In a corner of the room an aeroplane inverted and weighted with sand, as in Langley's method, was under test for stress and strain of its wing framing. In another corner was an apparatus for measuring the force applied to the controls of an aeroplane by pilot in practical flight. This instrument may help to determine the most suitable mechanism for a standard control.

The shop and the engine testing houses contain nothing that need be reported. The engine torque and thrust were measured by ordinary mechanical methods, and no special apparatus was used to furnish a stream of cooling air, as in the British laboratory.

Other German aeronautical laboratories worth passing mention are: the testing department of the Zeppelin Airship Company; the aerodynamic laboratory used by Prof. Reissner of the technical high school at Achen; the laboratory in charge of Major v. Parseval in the high school at Berlin; the experimental plant of Prof. Dr. Fr. Ahlborn, at Hamburg. The Zeppelin laboratory is not, under any consideration, open to visitors from abroad; and as to the others just mentioned, I had time only for a brief visit to Ahlborn's place. Ahlborn's experiments have been confined mainly to determinations of flow about models in a tank of water. The results are well portrayed in numerous excellent photographs and publications, the best of which are in the Smithsonian Institution. His apparatus and photographs and those at the National Physical Laboratory in England are, for hydromechanical studies, the most instructive that have yet come to my notice, except perhaps the more restricted ones of Hele-Shaw. For stream-line delineation in air, however, the classical apparatus and methods of Marey have not yet been surpassed, though more precise instruments of this nature are much to be desired.

To Make Nottingham a Port

The Manchester Ship Canal now being a paying venture, Nottingham is desirous of taking in hand the canalization of the Trent, with the idea of emulating, albeit on a smaller scale, the excellent example of Cottonopolis.

The scheme is already well advanced, and a bill will be introduced into Parliament to secure legislative sanction for the Nottingham municipality to expend the necessary £160,000 on the work—already begun in a small way by the Trent Navigation Company.

The directors of the company, with the limited resources at their disposal, have carried out works of far-reaching importance beyond Newark, enabling boats of from 100 to 120 tons to be brought thence from the mouth of the river, but once the confines of that historic borough have been reached something in the nature of a deadlock occurs, all the merchandise consigned to Nottingham or beyond having, of necessarily increased cost and sacrifice of time, to be transferred into smaller boats of 20 to 30 tons capacity. It is upon the tortuous and at present difficult stretch of the Trent between Nottingham and Newark, a distance of about twenty miles, that the corporation contemplates an expenditure of £160,000, and although, apart from railway and other conflicting interests involved, there are opponents of the scheme in Nottingham who predict that it will prove something in the nature of a white elephant. The ratepayers recently at a statutory meeting supported the policy of the council, the anticipation being endorsed that with the carrying out of the contemplated improvements in the navigation a satisfactory volume of traffic and consequent revenue would be annually forthcoming.

No formidable engineering difficulties stand in the way of completing the scheme, which is destined to form a substantial link in the chain of improved inland water communication which the Royal Commission on Inland Waterways has long been anxious to establish. The junction with the Trent and Sawley canal marks at present the upper limits of the company's navigation. Down the river there are junctions with the Loughborough navigation, affording means of reaching Leicester and onward through the Grand Junction Canal to London. Northward the company's authority ends at Gainsborough, the Humber Conservancy Board possessing jurisdiction from the mouth of the river to that center of engineering activity. The Newark Corporation, by a generous expenditure upon the river for three and a half miles of its length in the neighborhood of that town, has already set an encouraging example to the capital or county, the works there forming a portion of the undertaking leased to the company, who expended a large sum upon the construction of the new Cromwell lock completed between 1909 and 1911, possessing a length between gates of 186 feet and a width of 30 feet, and being so constructed that there would never be less than 6 feet 6 inches of water running through it. At an earlier date the Newark Trent lock was deepened by the company, giving sufficient breadth and length also to accommodate boats of 100 tons at all seasons.

The work which the Nottingham corporation has now in contemplation includes a complete revolution in the river between Trent Bridge and Newark by an extensive process of dredging, which it is estimated will cost £55,000, and the construction, at an expenditure of £76,800, of new locks at Stoke, Bardolph, Gunthorpe, Haselford, and Holme Pierrepoint, £10,000 of the total outlay involved being allowed for the work in relation to the Newark nether lock. In the two miles of water leading from Trent lock at Nottingham toward Newark not much remains to be done to meet the requirements of boats 100 tons, the major portion of the expenditure being necessitated on the stretch fourteen and a half miles between Hemelock and Fiskerton. This part of Trent is very shallow, and at points exceedingly rapid, the depth of the water available for navigation at times of exceptional drought seldom exceeding 2 feet 8 inches, while the vertical fall in the water level is no less than 21 feet, equivalent to 17 inches per mile. After leaving Fiskerton no great amount of dredging remains to be done. It is proposed to make all the new locks of the same size as that at Cromwell, the object being to allow a tug and its train of boats to be passed at the same time, and thus to get rid of the serious delay entailed by having to "pen" each boat separately. As four vessels could then be passed at the same time through a lock of the size proposed, this would be equivalent to about 800 tons of cargo.—*The London Daily Telegraph.*

It is now stated that by using a small percentage of the tar from oil gas as a binder coal dust can be satisfactorily briquetted, although explanation is given why this kind of tar should give successful results where all other kinds have failed.

The Protection of the Strong

A Discussion of the Working of Insurance Laws for the Protection of the Poor

Murmurs of dissatisfaction occasionally arise over the working of the German insurance laws for the benefit of the poor. There is especial difference of opinion as to the results of the legislation regarding the sick benefit fund, the laity and the medical profession looking at the question from two totally different points of view. The matter is discussed in a recent number of the German journal *Umschau* by a Dr. Jens Paulsen, who, after pointing out the trials of physicians in conforming to the laws concerning the sick insured poor, goes on to a general review of the whole subject of the preservation of weaklings, to which so much attention has been given by the German government during the last thirty years.

The sick-benefit insurance laws have a wide-reaching influence in Germany, for when the dependents of the insured are included 94.4 per cent of the population of the country are affected. Dr. Paulsen's complaint as regards this fund is that the working of the laws have enormously increased the labors of physicians while making them dependent on a few government officials; that, in short, the profession has had a most unpleasant disillusion. In former days the attending physician was the free choice of the patient, who selected the man in whom he had confidence; now the fund steps in between the two and assigns the patient and attending physician to each other. Owing to the great number of people who are obliged to call on the insurance fund in illness, this virtually makes a large part of the medical profession dependent for success in their calling on the good-will of a few administrators of the fund, hence the combats between the two sides. The writer claims that every physician who conforms to certain conditions laid down by the fund should have the right to cure medically for any patient who might desire him, as was customary in days before the fund existed. The other main grievance is that the fund has practically made all physicians in its employ health officers, who must spend the greater portion of their time in filling out blanks and making reports, the result being that such physicians are compelled to employ secretaries to their pecuniary detriment. For every patient, whether a case of serious illness, or a mere trifle as chapped skin, blanks containing innumerable questions must be filled out and certificates drawn up for the patients containing all forms of grants, from the right to the insurance money or permission to go out walking. The writer declares that he himself has had to fill out over a hundred different kinds of blanks, and it is only after this secretarial work is completed that the physician can give his attention to the medical care of the patient.

The patient is also unfavorably affected. He has to run to the physician for every trifle, as it is to his pecuniary advantage to get medicines free, and a medical certificate is generally required for absence from work. Thus, the poor are trained to dependence and helplessness in petty ailments for which formerly they would have sought remedies for a few pennies at an apothecary's, lose the sense of dishonor in living off the public funds, and fall often into the demoralizing habit of playing sick. To meet all these small demands the physician is frequently expected to be at his office in the evenings and on Sundays, so that the patient may not lose time from work. Consequently, the doctor has seldom time to keep up with the scientific advances in his profession, is often obliged, by the inordinate care which must be given to insignificant ailments, to neglect serious illnesses, and, what is probably the crux of the whole matter, is rarely paid for individual cases, but only a small lump sum for all the patients that must come under his care.

The main benefit claimed by social reformers from this system is that thereby the beginnings of illness are immediately treated and serious dangers to health are checked. The objections made by physicians are those just mentioned with the addition that the enormous sums expended by the fund are too largely paid out for petty cases while insufficient money is allowed for serious cases. In the opinion of the writer, inner reforms allowing more independence of action are required rather than a complete reconstruction of the benefit fund laws. The changes suggested by the medical profession have been rejected by the authorities and are regarded as not proved by the files and statistics. This Dr. Paulsen considers a blunder, for that which is essential cannot always be weighed and measured. The physician should be allowed more independence in practise and should not be forced to waste his strength on blanks and trifles. It would be well to apply to the insured the measures now adopted by private insurance companies, which no longer compensate small ailments as formerly and make the insured themselves take a certain part of the risk. It would be better if the patient had to pay a part of the cost of medicines, or even share in the expense of medical attendance. This would increase his interest in and respect for the work of the fund, for what costs nothing is seldom appreciated. Moreover, the son of well-to-do parents, who happens to have a small salary, should not be entitled to the benefits of the fund, nor should a young fellow receive the same insurance money as the middle-aged father of a family, because both happen to draw the same wages.

Similar difficulties have developed in the administration of other branches of social legislation, as in accident insurance; and attention is called to the increasing burden laid on large cities by the demands for social improvements.

The writer then takes up the further question whether it is possible to attain a healthful condition of the entire population by a development of the insurance laws, that is, by assuring the expense of prompt and sufficient care in cases of ill-health, in addition to the present measures preventive of the spread of disease. Preventive measures have removed the danger of certain contagious diseases, as the plague, smallpox, and cholera. Safeguards against accidents and inspection of workshops prevent industrial mishaps. Phosphorus poisoning of workmen is avoided by forbidding the manufacture of phosphorus matches. All these evils cause injuries to health through purely external influences. When it comes, though, to an attempt to uproot the tendency to illness inborn in the individual human being, the matter, in the opinion of the writer, is very different and universal biological laws come into play. The original cause inherent in the individual cannot be removed, and favorable external conditions develop it into illness. "For instance," says Dr. Paulsen, "a physically vigorous soldier, who is also apparently sound mentally, becomes in a war unbalanced in mind from the same fatigues and psychical impressions to which his comrades have also been exposed. This mental affection would probably not have appeared if he had lived continuously under favorable conditions. In such a case, consequently, the social preventive measures would have obviated the outbreak in times of peace, but could not in the least have done away with the inherited tendency."

The layman knows that peculiarities of mind and character and insanity are largely hereditary, but seldom thinks that physical illnesses are also frequently the result of inherited inferiority of physique; that a person with such hereditary tendencies can rarely fight out the struggle of life, or only does so under the constant aid of the benefit institutions, with the help of which he drags out a weary and disheartened existence.

There are many more persons thus heavily weighted than is commonly believed. As examples might be mentioned the army of people suffering from nervous diseases, gout, diabetes, etc. Hardening of the arteries is also hereditary in some families. Many sufferers from tuberculosis have also inherited the trouble, while an anatomical predisposition must be assumed at times for appendicitis.

In many cases of illness it is evident that the ill-health is not entirely from external accident. A good example is to be found in the mentally retarded. There are beings who have remained in a childish condition both physically and mentally, or, as more frequently happens, in whom one organ or one set of organs have never fully developed. Thus, it is common to find a small heart which works all right when not overtaxed, but which breaks down in illness or when much is demanded of it. It is like a small pleasure auto which has been turned into a motor van for heavy loads. To such persons may be added to the great throngs of those who are constitutionally weak on account of the alcoholism or syphilis of parents, as well as those who have contracted such diseases themselves. Experienced observers, therefore, believe the opinion to be correct which holds that a third of the population of Germany is imperfect in health.

The physician can often do no more than mitigate the sufferings of persons thus burdened. The extreme cases fill the endless succession of insane and other asylums, the homes for the crippled, deaf and dumb, and blind, all of which institutions yearly increase in number and size. The lighter cases, those able to work, are the persons who, above all, lay claim to the aid of sick benefit insurance and other social organizations. It is these classes of people who are the great source of expense to benefit funds and charities.

Consequently, the present social provision for the care of the weak often leads to the maintenance of the unhealthy elements of society at the expense of the healthy, and gives the former greater opportunity to reproduce their ailments in offspring. "Frequently," continues the writer, "children of the tuberculous are found who were born in the period after the first treatment by the insurance benefit. This treatment has often only slightly prolonged the life of the invalid, while it has aided in the bringing into the world of a large number of children. In the same way the cure of drunkenness is advantageous to the individual both economically and as regards health, but results in a deterioration of the population through the children born after the cure who have hereditary weaknesses. It would be a good thing if the insurance offices were to issue information as to the number of these children. Thus plainly the weaklings are favored in their perpetuation at the expense of the healthy through our efforts to protect them."

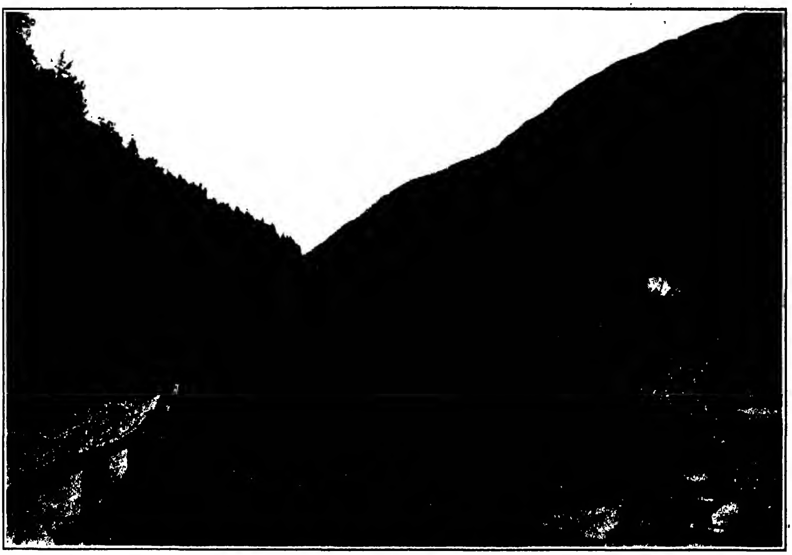
At the same time difficulties are often thrown in the way of the perpetuation of the good qualities of the healthy. In the higher circles of society many marry late or not at all. The German officer desiring to marry is obliged to inquire first about the fortune of the proposed wife, and not until afterward as to health and abilities. It is not merely training and examinations which can raise a class of society in the world; there is something also to be learned in life afterward. While a change of conditions described is greatly needed, it will be difficult to bring about, because it demands a knowledge of biological principles which the majority of even the educated people lack. There is still little understanding of the fact that inner causes contribute far more to health and good fortune in life than outer conditions. Even physicians lay too great a value on external factors. Another difficulty is the undue estimation of personal liberty. It should be better understood that the individual, as a citizen of the state must subordinate his personal life to the good of the whole.

Although the weak should be protected and cared for in every way, yet the demand must be made upon them in return that they cease to have children when it is medically proved that such children will cause deterioration of the race, and means should be taken to enforce these demands. On the other hand, marriage must be made easier for the valuable elements of the race, especially for those of mental ability. These problems are difficult and their full solution may never be attained. It would, though, take too long to wait until the entire nation came to understand the matter, for that would be to expose the country to the fate which all civilized peoples have suffered that have gone to pieces since the days of Rome, because the strong members of the population failed to perpetuate themselves, while the inferior part of the nation increased at the expense of the healthier and more valuable.

British Metals and Alloys

The cutting off of certain engineering supplies which formerly came from Belgium and Germany has been a very serious matter in many branches of the industry. The automobile manufacturers were particularly hit by the absence of light steel stampings and castings; so much so, in fact, that special meetings of the Institution of Automobile Engineers were held in London, Birmingham, and elsewhere, to discuss the position with a view to inducing British manufacturers to lay down the necessary plant for the production in large quantities and at a reasonable price of the various parts of which there was so great a shortage, and which heretofore have come from abroad.

Encouraged by the success that has attended this enterprise, the makers and users of metals and alloys that formerly came from Belgium, Germany, and, in fact, from foreign sources generally, arranged for a meeting in Birmingham. At this meeting there were extensive exhibits of all kinds of British-made metals and alloys both in the worked and unworked states. These showed very clearly that it is no longer necessary for manufacturers to depend upon foreign supplies. Samples of the various metals used in the production of alloy steel and pure nickel in the form of wire, crucibles, cylinders, and so on were exhibited, together with rarer metals, such as cerium (used for automatic lighters of the friction type) and tungsten. The latter metal was largely imported from Germany, but is now being made here in large quantities, particularly for electric lamps and for hardening steel.—*The London Daily Telegraph.*



The "Chestnut" Viaduct across the Rhône.

The Furka Railway

A New Alpine Railway from the Rhône to the Rhine

By Dr. Alfred Gradenwitz

The district traversed by the Furka Railway, which connects the Rhône with the Rhine, has the most varied attractions in store for the genuine lover of Alpine scenery; moreover, the country bordering upon the new line is historic ground of the Swiss Confederation. The scenery along the actual line, although of a sterner kind than that of many parts of Switzerland, has nevertheless certain qualities, difficult of definition, which give it a stronger and more permanent hold on the affections and imagination than the milder contours and more luxurious growths of other regions. The mountain passes in the surrounding district—the Gothard, Simplon and Grimsel— are the most famous in the Alps. As for the Furka itself, below the summit of which the new line runs, without, however, disfiguring its natural beauty, this is one of the most beautiful of Alpine passes.

The new railway starts from the old Valaisan town of Brigue, the well known railway junction for the Simplon and Lötschberg lines. Brigue is situated in the Rhône Valley, a valley more than 100 miles long, which leads from the Rhône Glacier to Lake Geneva, characterized by the long, straight line of the turbid waters of the river and by long straight roads bordered by equally long rows of Lombardy poplars. Every town and village, almost every hamlet, has its history, usually one of blood and fire, battle and sometimes murder.

Immediately behind Brigue station, the line passes below the Federal Railway and crosses the Rhône on a bridge of its own, reaching the ancient village of Naters, which, being occupied by a colony of Italian tunnel workers, is distinctly picturesque. On one side of the valley is the Furka line, and on the other the Simplon line, with the entrance to the longest tunnel in the world. For a time the line follows the old Furka Road passing through a fertile valley, where fruit trees and gardens are plentiful. Spanish chestnuts grow about the hillside, and Indian corn and melons flourish in the gardens in summer. After crossing the Massa, one of the turbulent tributaries of the Rhône, the railway reaches Z'Matt-Bitsch and follows for a while the concrete conduit which supplies water for operating the turbines of the Simplon tunnel.

Throughout most of the valley, in fact, throughout the greater part of the Valais, the fields are kept green, even in a hot, dry summer, by means of a multitude of little irrigation canals, mostly of great antiquity. After leaving Mörel, the line passes over two of the thirty-four viaducts of the Furka Railway, beside which there are thirteen bridges and two loop tunnels.

The Rhône is now crossed on the picturesque "Chestnut" Viaduct, after which the line rises considerably, the first cogwheel section beginning here. This leads toward Grengiols, which is left high up to the right, and on a lofty viaduct about 330 feet in length, crosses the road and river, reaching a high mountain slope at right angles to the straight valley. Round this obstacle the Rhône turns in a large loop far below; the road (to the south) winds slowly upward in zigzags, and the railway disappears to the north in a loop tunnel 2,000 feet long, reaching the height of Deisch, by another cogwheel section and tunnel.

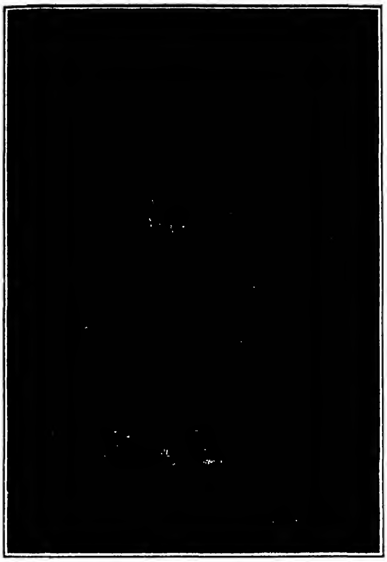
The Fiesch Valley is now entered, through which runs the Fieschbach (or White Waters), a glacier stream and a tributary of the Rhône. Several more viaducts are then crossed, before the summer resort of Fiesch (3,493 feet altitude) is reached, the starting point for a number of mountain excursions.

After leaving Fiesch, the Furka Railway proceeds for some way through larch and pine woods. Looking backward, there is a fine view of the Weisshorn *arête* and cone, and glimpses of the Diablon and the Fiesch glacier. The line then continues in a wide curve, again in a cogwheel section, with a splendid view on the Fiesch Glacier and the village of Bellwald situated at a lofty height, and after crossing the Fieschgraben Viaduct, climbs up the mountain slope. Passing close to the Rhône, we soon notice Niederwald, half hidden behind a fold of the mountain, and rapidly pass through a long succession of small hamlets, all turned on the northern slope toward the often sparing sun.

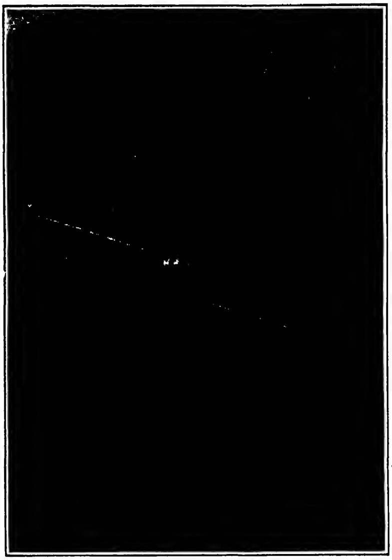
The valley widens out more and more, and no little spot is left uncultivated, though the rude climate in those heights (3,900-4,000 feet) only allows grass and a little rye, barley and flax to thrive. One of the next stopping places is Ulrichen, a military station, facing the Eginental, a valley leading to the well-known passes of Gries and Nufenen, used in olden days, like the Albrunn Pass, by Italian wine carriers transporting wine to the cellars of Berne. Plans have been made for constructing a railway from Ulrichen over the Nufenen Pass to Airolo on the Gothard line, thus effecting a connection between the Valais and Ticino. The Furka Railway also touches Oberwald (4,497 feet), the highest village in the Upper Valais, and a summer resort. This is the furthest point to which the railway runs in winter. The line now enters the narrow gorge which terminates at Gletsch (5,778 feet), situated at the bottom of the Rhône Valley, with the Rhône Glacier in the near distance, the Furka Pass on the right, and the Grimsel on the left. Gletsch is the celebrated crossing of the Grimsel and Furka roads, the former of which still is the uncontested realm of the mail coach.

Before reaching the Furka tunnel proper, rather over a mile in length, which runs immediately below the Furka Pass, at 7,138 feet altitude, there is Muttbach, whence a good road leads to Hôtel Belvédère and to the upper edge of the Rhône Glacier. From the summit of the Furka there is a splendid view on the Bernese and Valaisan Alps on the one hand and the Ursern Valley with the Urner and Gothard peaks on the other. The Mutthorn can thence be reached in 3 hours. Beyond the Furka Pass there is Furka Station, whence a new military road at Tiefenbach reaches the Furka road proper.

The railway now descends the slopes of the Reuss, here but an insignificant stream. Shortly before the Angerton chalets are reached the Wyttenwasser Valley opens to the right, leading to the glacier of the same



Picturesque Fiesch, with Alpine stream in foreground.



Lofty viaduct crossing the Rhône near Grengiols.

name. The village on the left is Realp (5,060 feet), a pleasant little place in a plain, which is a stretch of dazzling snow in winter, and of flowery meadows in summer. We now reach Hospental, whence the Gothard road branches off southward, and soon after Andermatt, the station of which is to serve at the same time for the Schöllenen Railway (Andermatt-Göschenen) now under construction. Immediately behind the station, the Furka passes over the Gothard tunnel.

We now take another lofty ascent—in three loop tunnels—to the summit of the Oberalp Pass (6,742 feet), whence we enjoy the wonderful scenery of the green Urseren Valley with the surrounding mountain giants. The pass here forms a lengthy defile with a melancholy little lake. At the end of the Oberalp Plateau there rises the Calmot (7,590 feet) the eastern foot of which is encompassed by a number of military buildings. To the right there is a footpath leading into another country and another valley, that of the Rhine, in the Grisons, where Romansch-speaking people live.

The railway continues its course on a slight slope high above the road and affords a welcome opportunity of admiring the "Piz" or peaks of the western Gothard massive. Below our feet, we see once more human dwellings, chapels and somewhat lower, on the banks of the foaming Rhine, a picturesque group of villages—Sul, Crestas, Selva—wholly embedded in flax and barley fields. As far as the eye can see, there is an endless stretch of verdure and woods. Beside every cluster of *châlets* will be noticed certain curious, wooden roofed structures, the use of which is not at first plain; but at this altitude, and with so little warmth, the corn, although it will consent to grow, cannot be ripened, and therefore it is hung up under the shelter of a roof, to be properly dried and continue its ripening process. The struggle for life here is keen indeed, but as the descent into the Grisons proceeds, the scenery becomes every mile less severe, the line often running through pine woods, and the valley broadening out greatly. The principal place before Disentis is reached is Sedrun, at 4,730 feet altitude, shortly behind which the railway traverses a broad sweep of flat, fertile land, with paths leading in all directions to the small brown-roofed villages dotted about in all the more sheltered corners.

Disentis, at 3,700 feet altitude, the terminus of the Furka line, probably takes its name from Desertinum (desert). Its most striking feature is the white Benedictine abbey, the oldest Benedictine foundation in Switzerland, which was probably established in 614, by the Irish monk Sigisbert. The abbots of Disentis acquired in the middle ages much power and importance, and one of them even attained to the dignity of a prince of the Holy Roman Empire. Besides being a place of great historical interest, Disentis is a spa, possessing the most powerful radio-active springs in Switzerland, and an excellent center for mountain excursions.

On account of local conditions the idea of operating the line by electricity had to be abandoned, steam being found more economical. The Furka Railway is 97.1 kilometers in total length, of which about 32 kilometers, with gradients of 70-100 per cent are cogwheel section on the Abt rack system, which allows a remarkable speed to be obtained.

Above the railway is a flume, carrying water to operate the electric plant of the Simplon tunnel.

The viaduct leads to the mouth of a long loop tunnel; the carriage road zigzags above.

Atoms and Ions—V*

A Comprehensive Discussion Especially as Related to Gases

By Sir J. J. Thomson, O. M., F. R. S.

Continued from Scientific American Supplement No. 2055, Page 327, May 22, 1915

At the Royal Institution, Sir J. J. Thomson, O.M., F.R.S., in delivering the fifth lecture of his course on "Atoms and Ions," recalled that on the last occasion he had referred to the slight conductivity which air possessed, and maintained even when confined within a closed and thick-walled vessel. In no way whatever was it, he said, possible to reduce this conductivity below a value which corresponded to the production of about four ions per cubic centimeter per second. If, instead of using air inclosed in a thick-walled vessel, a sample of free air was taken, the conductivity was very much greater than corresponded to the above figure. In fact, with air in its normal state, the number seldom fell below eight ions, and might rise to a much higher value. This additional conductivity was due to the radioactive constituents of the earth and atmosphere. These gave off emanations which were capable of ionizing a gas, and to the presence of these emanations was to be attributed all the conductivity in excess of that corresponding to the production of four ions per cubic centimeter per second. As would naturally be expected, this added conductivity showed considerable fluctuations, being dependent on the presence of a gas which had originally come out of the earth and been carried by the winds to the site of the experiment. The quantity of this constituent present in the air had been measured by Satterly at the Cavendish Laboratory daily for nearly a year, and he had found that its amount ranged from a minimum corresponding to the production of one ion per cubic centimeter per second to a maximum some ten times as great. Satterly had tried to establish some connection between the amount of this constituent present and the state of the weather. But no very close connection was apparent, the weather, whether wet or dry, calm or windy, making little difference to the conductivity. In fact, the gas sampled at any one time might have traveled hundreds of miles. The constituent responsible for the extra conductivity, though not permanent, could last a week or so, and hence the conductivity of the air examined at a particular time might have been acquired a week or two previously. In this connection it was therefore the atmospheric conditions at the sources of supply, rather than those at the testing place, which might affect the conductivity. Hence, no very close connection was to be expected between the conductivity of the air and the state of the weather, and none was apparent. When, however, the course of the air was traced back, for some time previous to the test, by means of meteorological charts, it turned out that in air which had traveled over continents the amount of emanation was much higher than that in air which had come from over the sea, the difference being very considerable. Another point established was that, when the barometer was falling, there was a tendency for the conductivity of the air to rise, due to the liberation of gas from the earth under the diminished pressure.

Mr. Satterly further found that the gas sucked out of the earth through pipes sunk to different depths in various parts of Cambridge was a very good conductor, being about two thousand times as conductive as ordinary air. This was due to the fact that the radium constituents of the soil were constantly giving off emanations, which collected in the pores of the soil, and, when sucked out, this emanation produced a gas which was quite a good conductor of electricity. Mr. Satterly found, moreover, that the marsh gas liberated on stirring up muddy ditches was also a very good conductor, as it brought with it the emanation which came off from the radium constituents of the mud. The amount depended, of course, on the quality of the mud, but very often marsh gas thus obtained had a very large amount of conductivity. From experiments made above land surfaces it appeared that the quantity of radium emanation in the air was sufficient to produce per annum and per cubic centimeter of air, 8×10^{-11} cubic centimeters of helium. The amount of helium actually present in the air was 5×10^{-6} cubic centimeters per cubic centimeter of air. He would not, Sir Joseph continued, divide the one figure by the other in order to determine the age of the earth, since a good many intermediate steps were missing between the emanation and the helium, which would have to be made good before a calculation of this kind could be justified.

In the last lecture he had alluded to the ease with which sodium and potassium and the alkaline metals generally came off (with a positive charge) from surfaces. He had meant to illustrate this experimentally, but the tube had cracked. He would not, however, make good the omission. The only peculiarity about the tube used lay, he said, in the electrodes. The positive electrode consisted of a piece of tubing, the upper end of which was tightly packed with a mixture of sodium iodide, sodium bromide, lithium iodide, and lithium bromide. A wire embedded in this mixture formed one terminal of the tube. The cathode consisted of a wire, which encircled as a spiral the tube forming the anode. When the discharge passed, the salt mixture was heated, and gave out rays consisting of atoms of sodium and lithium, which moved fast enough to give the characteristic colors of these metals, viz., the yellow of sodium and the red of lithium.

Proceeding, the lecturer next discussed the means by which solids and liquids which were ordinarily insulators might be made conductors. This could be done, for example, by means of the Röntgen rays. The resultant conductivity was in no case equal to that produced by the same means in a gas, but it was still quite appreciable. In the early days of Röntgen radiation he had himself observed that these rays would render conductive a mixture of vaseline oil and bromine, which ordinarily was a very bad conductor. Similarly, hexane exposed to radium became quite a good conductor of electricity. Jaffe had in this case measured the number of ions produced and their speed, and also the rate at which ions of opposite sign combined to form new systems. In some respects hexane was more satisfactory to work with than gases, as, although the conductivity was smaller, the results were found to be more regular.

The Curies had shown that insulating liquids and solids exposed to the radium emanation also became conductors. McLennan, again, had found that when exposed to the influence of polonium, liquid air would conduct electricity. He would have liked, the speaker continued, to have shown this experiment, but owing to the difficulties arising from the condensation of moisture in the apparatus, and consequent loss of insulation, the plant required was too cumbrous for use in a lecture experiment.

Dewar had shown that, normally, liquid air was an insulator, yet McLennan now found that it would conduct when exposed to polonium. The speaker would, he said, use polonium to show that under its influence paraffin would become a conductor. To this end Sir Joseph placed a sheet of paraffin paper on a copper plate coupled to an electroscope, and on top of this paper laid another sheet of copper, on one side of which was a deposit of polonium. He showed that the leakage from the electroscope was about three times as fast when the polonium deposit was next to the paraffin as when the plate was reversed upside down.

There was another substance, the lecturer continued, which became a conductor when exposed to Röntgen rays, but he would not claim that this was a simple case of ionization, although probably closely connected therewith. He referred to the action of Röntgen rays on a selenium cell, which under the action of the rays had its resistance very largely reduced. The cell was made by cutting a series of equally-spaced notches on the opposite edges of a strip of mica, the most convenient plan of doing this being to clamp the mica between two pieces of brass, turn up the whole on a lathe, and finally cut a screw-thread of 1 millimeter pitch. Around the strip thus formed were wound two coils of wire, the two wires resting in alternate notches. The whole was covered with selenium and warmed until the selenium flowed over and filled the interspaces between the two windings. It should be noted that it was only the crystalline form of selenium that was sensitive, and the attainment of this state was indicated by the appearance of the selenium, which in the crystalline condition was slate-colored.

Taking a cell thus formed, the lecturer placed it in a light-tight box, coupling up one coil to a voltaic cell, and the other to the terminals of a galvanometer. On exposing the box to the action of Röntgen rays he showed that the deflection of the galvanometer was notably increased, the resistance of the cell being, in fact, diminished to about one third of its original value. Great as was the effect of the Röntgen rays on the cell, that of light was, he continued, very much greater, a lighted match brought near the cell causing a very large deflection. Many practical applications of this property of selenium has been proposed, including a method for the transmission of photographs telegraphically.

Resuming, the lecturer said that it would be seen from the foregoing that by the action of appropriate agents we could get conductivity in liquids and solids as well as in gases. Indeed, we should expect that it ought to be easier to effect a separation of the positive and negative charges in the case of liquids than in that of gases, or, rather, than in the case of the individual molecules constituting the gas. The electrons or corpuscles inside the molecule might be looked on as exerting a certain pressure, the intensity of which was peculiar to the particular element under consideration. Thus, with iron the pressure had one value, and with copper another. If an atom of the one were put close to an atom of the other, the fact that the internal corpuscular pressure was different in the two atoms would tend to make corpuscles pass from one to the other.

What was it prevented this flow of electricity? A transfer would mean that the one atom would be left positively changed, and the other acquire a negative charge, so that the two would be equivalent to the two coatings of a Leyden jar. Now, when a Leyden jar was charged with a definite quantity of electricity, the larger the jar the smaller was the work required to charge it, this work being, in fact, inversely proportional to the capacity of the jar. Hence, the resistance offered to the transfer of a charge from one system of molecules to another would diminish if the size of either of the systems involved was increased. A collection or cluster, consisting of a large number of molecules, would thus correspond to a large jar, and to charge it up with a definite quantity of electricity would need a smaller expenditure of energy than would be required by the smaller jar represented by single molecules. Hence, it should be easier to get the electricities separated when dealing with clusters, or aggregates of molecules, than when dealing with two individual molecules, and when molecules were closely associated together, as in liquids and solids, than when independent, as in the case of gases.

It was not to be supposed that every molecule of a cluster lost a charge, but merely that the transfer of a single charge took place more easily when a considerable number were aggregated into a cluster. In other words, it was more difficult for atoms of iron and copper to become charged up when brought into contact than for plates of the two metals to do so.

When two dissimilar bodies were brought into contact, there was thus a tendency to produce electric separation, one side becoming positive and the other negative, and this tendency was the basis of the process of producing electricity by friction, the work expended in the friction providing the energy necessary to complete the separation by tearing the charges apart.

A remarkable phenomenon had been discovered by Quincke, who had found that small particles of solids floating in water or other liquids were set in motion by an electric field, sometimes in one direction and sometimes in the other, depending upon the nature of the particles, and on that of the liquid in which they were suspended. For example, particles of sulphur suspended in turpentine contained in a horizontal tube could be driven from one end of the tube to the other by coupling up the ends of the tube to a Wimshurst machine. On reversing the polarity of the ends the particles previously crowded into one end were rapidly cleared out and driven to the other end, and similar phenomena could be shown with particles suspended in water.

Consider, Sir Joseph said, such a particle in suspension carrying, say, a negative charge distributed over its surface. Then, on the adjacent water there would be a layer of positive electricity equal in quantity, and if any external force acted, it would push the positive as much as it pulled the negative layer. Hence, if the charges were rigidly connected together, there would be no effect. Yet, as a matter of fact, in most cases the particles did move through the liquid, and this was supposed to be effected by the outer layer of electrification slipping past the particle, and being made good as renewed by a fresh charge induced on the water molecules, which replaced those left behind by the motion of the particle.

If this were really the nature of the action at issue, it would seem as if there should be some limit to the

* Reproduced from *Engineering*.

conditions in which it might occur. His own view was that if the potential difference between the two coatings was sufficiently great, no motion would occur, and, of course, there would also be no movement if this potential difference was zero. It was, indeed, a suspicious fact that measurement made of the speed of these particles (which was proportional to the potential difference) showed that the speed did not depend on the size of the particles, but only on the potential difference, and the numbers deduced for this were all about 0.08 volt; the highest of which he could find a record being 0.05 volt in the case of copper particles in contact with water. This scale of values was just in the region of the energy possessed by the particles in virtue of their thermal agitation, that of the particles of air being 1/30 volt when measured on this scale. It was, he thought, very suggestive that the numbers found were all in this neighborhood, and it might be that the separation of the charges which permitted the motion, had to be brought about by the energy which the molecule possessed in virtue of its thermal agitation. Hence, if the energy required to separate the two coatings were very large compared with the kinetic energy of the particles, the two coatings would be held together, the particles would not move under the action of the electric field.

In the Cavendish Laboratory, Mr. McTaggart had experimented on the motion of electrified bubbles through a liquid, and, using centrifugal force to steady their motion, had observed their velocities with very great accuracy. An interesting point established was that the speed due to the electric field was the same whatever the gas in the bubble, whether oxygen, hydrogen, or air. Possibly this result was due to the difficulty of getting entirely rid of oxygen, very little of which might, perhaps, suffice to mask any specific velocity.

(*To be concluded.*)

Tide Analysis—A Simple and Inexpensive Apparatus[1]

By Ernest W. Brown, F.R.S.

The object of this paper is the description of an apparatus for the analysis of tidal observations which anyone may quickly construct for himself at an expenditure of a dollar or so. Darwin's well-known apparatus[2] has disadvantages which he himself recognized. It consisted of strips of xylonite on which the observations were written, and of guide sheets carefully printed to show the positions in which the strips were to be placed for the evaluation of any particular tide. He had these made for a year's observations and about a dozen different periods; each sheet was to serve for seventy-four days and there were thus some sixty large sheets to be used.

The device described here is intended to obtain precisely the same result as that of Darwin. The strips are replaced by endless paper bands and the guide sheets by simple instructions for arranging the bands and for testing the correctness of the arrangements. The simplification is partly due to the introduction of adding machines, now in practically universal use where large masses of additions are to be performed. With them it is no longer necessary that the digits should be very accurately in column for easy addition; so long as the complete numbers are sufficiently nearly in a column as not to be confused with numbers in a neighboring column, the operator has no difficulty in following his work: with accurately ruled paper, however, the numbers can be put into accurately placed columns as easily as in Darwin's method. Nothing else in the device requires any great care. As its successful use depends mainly on small details, I have described the latter somewhat fully. There is also another reason for this. Experience has shown that a considerable proportion of the time of the operator is often taken up with the arrangement of his work, frequently more than the actual calculation. There is thus more opportunity for the saving of time and trouble and consequently expense (which is now the chief factor in reducing tidal observations) by the simplification of the arrangement of the work, than in any other part of it. An apparently trifling detail in operation may make the difference between success and failure in this respect.

The materials required are ruled paper, sheets of cardboard, paper cutter, a few brads and double-pointed tacks, and a board.

The ruled paper should be of good quality with smooth finish and not so heavy as to prevent it from folding easily. The horizontally and vertically ruled lines are to be uniformly a quarter of an inch apart. This size permits two figures to be written in each square with no parts of the figures projecting over the ruled lines.[3] Its width is to be 19 inches (72 squares + an inch overlap) and height at least 8 inches (32 squares).

The cardboard should be fairly flexible so that if bent into an arch whose height is about one sixth of the base, it will not tend to break and will return to its original form when released. The height of the card should be about 12 inches, its width rather less than 9 inches. The latter measurement is to be such that when two sheets of the ruled paper are folded closely over it one edge of the outer sheet shall come accurately over the ruled line on the sheet 18 inches from that edge.

A cover to the cardboard is made by folding a sheet of the same kind of paper (ruling is unnecessary) closely over it and pasting the edges together, care being taken that the cover does not stick to the cardboard. If the latter be bent a little the cover can easily be slipped off and on.

A convenient paper cutter is that used to trim photographs; it must be large enough to make a 9-inch cut.

Four brads are driven into a board so as to form a rectangle about 8 inches by 9 inches. They should be a little inclined inward along the direction of the 8-inch sides of the rectangle. The double-pointed tacks are partly driven in close to the brads with their lengths in the same direction, so that when the sheet of cardboard is bent and the edges placed between the pairs of brads it will remain bent and will be slightly raised above the board. Each brad and tack may be replaced by a small wood step nailed to the board.

In Darwin's scheme for the analysis of a year's observations, hourly heights are used. He also suggested that such units should be adopted (e. g., tenths of a foot or inches) that all heights could be expressed by two digits. It is convenient to describe the use of the apparatus on this basis, although there is room for four digits if necessary. The twenty-four observations for the first day (day 0) are written in every third square of the top line of the ruled paper beginning with the third square from the left and ending with the seventy-second. The second and succeeding days are similarly written in the following lines up to the end of the first block, which, for the solar tides, contains thirty days. At the end of several of the blocks one day of observations is not used for these tides: it must, however, be inserted. Thus, twelve sheets contain all the observations: these may be written in, as they are measured from the tide curve. They are then summed according to Darwin's published instructions, both horizontally and vertically, and the results used for the analysis of the solar and long-period tides.

For this and future arrangements, the number of the day is written in red ink twice on each line in any one of the unoccupied squares, once between the left edge and the observation for 11h and once between the observation for 11h and 23h. A pair of single red lines is ruled so as to inclose all the observations at 0h and a pair of double red lines to inclose all those at 12h.

The observations have now to be regrouped so as to give an analysis for mean lunar time. For this purpose the first sheet is placed face down on the table and the two edges folded over so that the left edge comes on to the ruled line following the observations at 23h. It is pasted in this position by using the inch overlap, care being taken that the inside portions of the paper do not stick together; the position of the folds is immaterial. The folded sheet is then placed on the paper cutter and each day of observations is cut off; it will form a closed band. The first thirty-seven of these bands are placed in order on the paper cover, previously made, by bending the cover in one hand and slipping the bands on with the other. The cover carrying the bands is then flattened out and the sheet of cardboard bent and slipped in. The remaining nine cards, each carrying thirty-seven days of observation, are treated in the same manner. Thus the whole year's observations are contained on bands stretched over ten cards.

The bands have now to be arranged in accordance with a scheme made out in advance. Suppose that the arrangement required is such that the observations at the following times are to be brought into the same column: 0d, 0h; 1d, 1h; 2d, 2h; 3d, 3h; 4d, 4h; 5d, 4h; and so on. The first card with cover and bands is bent and the edges placed between the brads on the board, care being taken that a band does not rest on the tacks. Any band is then easily movable around the card; it can be rapidly and certainly brought into any position by gently pressing on it with a piece of soft red rubber and sliding it to the right as required.[4] If the band be pinched over the edge of the card when it is brought into position it will remain there while the other bands are being placed. The card and cover being about 12 inches long and the sum of the widths of the thirty-seven bands being only 9.25 inches, there is ample room for the movement of the bands, it being not necessary that they should lie very close to one another.[5] The remaining nine cards being treated in the same way, the observations are ready for the summing which gives the M series of tides.

The other rearrangements follow a similar process; a separate set of instructions for the ordering of the bands is given to the operator for each arrangement. After the process is completed the cards are slipped out of the covers carrying the bands, and the latter can be stored away in an envelope on which it is only necessary to write the year and the port. The observations have thus only been written once and are always available for future reference.

If the observations be typed on to the sheets, the dimensions of the apparatus may be conveniently reduced in the ratio 3 : 2.

It remains to explain the instructions to be given to the operator. The single and double pairs of red lines and the number of the day are the guides; one pair and one day number will be found on each face of the card when the bands are placed over it. Define "no step" for any day as a case when the observation at 0h on its band is immediately under that for 0h on the band next above, and the "one step left" when that at 1h is immediately under that at 0h on the band next above. Similarly for "one step right." The words "left" and "right" need not be repeated since there are never both left and right steps with any one tide. The instructions to the operator consist only in giving to him the step for each day, and some other fact which will enable him to test his work. The method of obtaining the instructions and the test will be explained by giving in detail those for what Darwin calls "mean lunar time."

The speed of this time in degrees per mean solar hour is 14.492052 degrees. It therefore moves 347.80925 degrees in twenty-four hours. This, on division by 15, shows that 23.187283 mean lunar hours are equivalent to 24 mean solar hours. As we can only use observations at exact solar hours, the position of the band on day n is obtained by finding the nearest integer to

$$(n + \tfrac{1}{2})\, 23.187283,$$

the approximate coincidence being made in the middle (12h) of each day of observation. Thus, for days 1, 2, 3, 4 the red lines must be one step left of those on the previous days, respectively, for day 5 no step, for days 6, 7, 8, 9, 10 one step left, for day 11 no step, and so on. The whole series is obtained by converting 0.187283 into a continued fraction. The successive convergents are

$$\frac{1}{5},\ \frac{2}{11},\ \frac{3}{16},\ \frac{53}{283},\ \frac{162}{865},\ \ldots$$

The third convergent shows that the successive 6th, 5th, 5th days are to be no-step days, while the fourth convergent shows that for 283 days there must be eighteen cases in which the no-step day is the 6th and thirty-five cases in which it is the 5th ($18 + 35 = 53$, $18 \times 6 + 35 \times 5 = 283$). We have thus the series 6, 5, 5, repeated seventeen times, then 6, 5, and finally 6, 5, 5, to the end. The above examination of the first eleven days shows that the first no-step day is day 5, the next day 11, which facts give the start of the 6, 5, 5 series. It is easy to run through and find the days on which 0h comes into the first column. Thus the instructions to the operator are as follows:

"Place each band one step to the left of the previous band except on the following days when no step is to be made: 5, 11, 16, 21, and thereafter the 6th, 5th, 5th in succession until the no-step day 277 is reached. The days 283, 288, 294, 299, 304 are no-step days and thereafter the 6th, 5th, 5th in succession until the end. For testing the arrangement, note that the observations at 0h for the following days are in the same column: 0, 29, 58, 59, 88, 118, 147, 177, 206, 236, 265, 295, 324, 354."

Similar instructions may be made out for the other periods.

This apparatus is more convenient for tidal analysis than that which I described[6] some years ago and which has been continuously in use for the synthesis of the small terms in the moon's motion which are to be inserted in the lunar tables. It is not, however, applicable, like the earlier device, to general harmonic analysis.

[1] From the *American Journal of Science*.

[2] Roy. Soc. Proc., A, vol. 35, p. 345, 1883, Sc. Papers, vol. I, 216.

[3] I have found two figures between ruled lines a better guide to the eye than one figure between closer rulings, especially when dealing with numbers of several digits.

[4] If slid to the left there may be trouble owing to the inside pasted edges of the band catching on the edge of the cover.

[5] If the cover be made of fairly stiff paper, the cards and the board may be dispensed with and the bands moved by one hand while the other holds the cover. But this method is not quite so convenient for use.

[6] Monthly Notices R. A. S., vol. lxxii, pp. 454-463.

Making Museums Useful

What an Active Curator Can do for a Small Collection

By Harlan I. Smith, Geological Survey, Ottawa

For many years we have all heard an almost constant complaint from museum curators and others interested in museums, that there was not sufficient money available for the purchase of specimens, the erection of the desired building, and the building of cases. It is true this complaint was not always, though often, made as a sort of apology for the lack of arrangement and labelling, the presence of dirt, and the failure of the museum to be very useful to the community, or even interesting to the average visitor. Some museums spend thousands of dollars for specimens annually for many years in succession, while their exhibition halls lack sufficient labels of all kinds, and especially the general divisional labels and case labels which are among the first needed to make a museum useful to the public. It were better to buy a 5 cent book to read. After all, a museum may better do without many specimens than to be lacking in the most essential labels. One specimen such as a diamond or elephant may not only cost more than thousands of equally instructive specimens, such as a piece of coal or a kernel of corn, but will use up more of a museum's funds than would be needed to completely label a large part of a great museum or an entire small one. So many institutions waste so much time in discussing what color, and weight of cardboard or other material will be used for labels, that many years pass before any exhibit is adequately labelled, whereas it would be better to label it with written or typewritten labels on any kind of paper, so that the present generation may get useful services from the exhibit, and to replace these tentative labels whenever a better kind has been found. In this way contemporaneous generations may derive benefit from the museum, which under the usual existing method is lost to them through providing for future generations. Personally, I doubt if those who follow these methods will deliver the benefits promised.

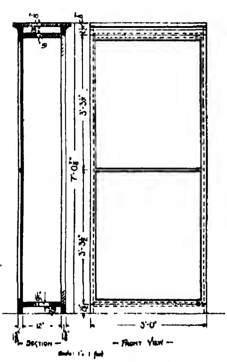
Waiting for a fire-proof or permanent or larger building is certainly a waste of time. I once knew of a professor who complained that he could not teach a number of interested students because he had no class room, but I believe I can recall hearing of certain great teachers of antiquity, who taught their disciples by the roadside, without either class room or place to lay their heads, and this idea also applies to museums, for after all, the whole outdoors is the best museum. A corner in every school-house may be a museum; a nook in every board of trade building may serve the same purpose; even the Sunday school room may have its little museum. Much may be learned in both churches and saloons. A cheap inflammable building may be a more useful museum building than a fire-proof structure costing millions. In an inflammable building it would not be wise to store valuable material, but in it could be displayed labels, pictures, maps and books illustrated by such cheap and common specimens as elm leaves, squash seeds, broken pebbles, English sparrows, mice, and the skull of a dog. A museum of such specimens accompanied by appropriate labels, books, maps, pictures and models, might easily be of more service to a community than some existing museums costing say ten times as much.

Cases in which to put specimens delay curators not months but years. First there is the discussion as to what kind of a case and how to make it dust proof; what the material, and the color of the background. In this way, while waiting for cases, years go by. People who would use the museum grow old and die. Children who have time in their receptive condition of mind to profit most in the museum grow up and have their time otherwise occupied. As a matter of fact, all these people could have gotten the maximum amount of benefit from the museum, had the specimens been exhibited without any case at all, on the wall, on tables, on the floor, or even out in the big out-door world, had there been sufficient and appropriate labelling.

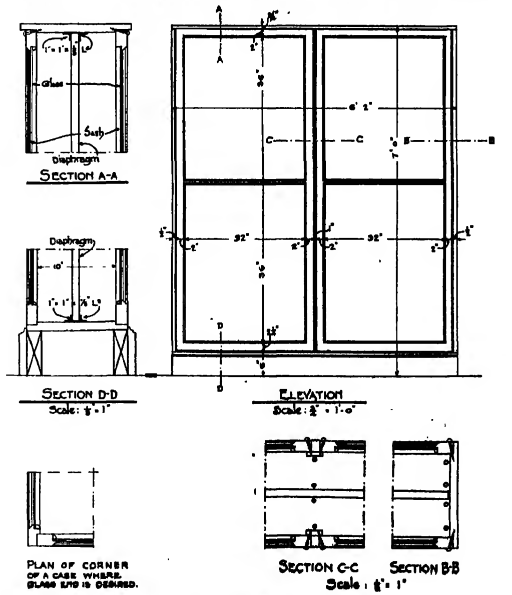
No doubt the background should be carefully considered, and that certain colors are better than others. Perhaps the relationship of colors or general harmony and the relationship of light and a subdued quietness of color are of extreme importance, but visitors in a museum where the cases were entirely white have been interested and obtained useful information some time before nothing whether the cases were white or black.

The museum of the Natural History Society of New Brunswick, located at St. John, has a comparatively small amount of money to spend each year, and its curator has not had the great amount of university education and travel enjoyed by some curators of larger and richer museums. In this his museum is perhaps fortunate, for in so far as his funds permit he is actually putting in force some of the most up-to-date museum methods. He has insufficient help, a comparatively poor building and miserable cases, yet he carries on field research, conducts a lecture course for adults and one for school children, giving two lectures per week during the school season, takes out large parties of young people to investigate and study in the field, issues some publications, identifies material collected by school children and sent to him by their teachers, and provides the teachers of the schools with nature study leaflets suggested by the objects sent within 24 hours of their receipt.

Every fall when the Canadian Pacific Railway supplies two cars filled with exhibits under the auspices of the provincial government of New Brunswick, to be drawn over its lines and side tracked for a few hours at each station where an audience may be had, this live curator accompanies the train. One of the cars usually contains exhibits of pigs, chickens and other live stock; the other exhibits relating to agriculture, such as bees, nursery trees, cream separators, and whatever the Government experts consider may uplift the agriculture of the province. Our curator friend installs material from his museum, supplemented by specimens collected for the purpose. These specimens show such things as birds which benefit the farmer's crops, insects which damage them, and drawings which he hastily makes with cheap materials, but which may be fastened up around the walls of the car or held up while he lectures to the rural audiences on things which will make their work more successful not only to themselves but to their province, and which will make their lives more interesting and pleasant while they are at work. No cold blooded corporation like the Canadian Pacific Railway would furnish a two-car train, man it and haul it for about a month each year, did they not believe it would make the people who visit it more prosperous, so that they might spend more money in shipping freight and traveling on the railroad. He has had an ordinary carpenter remodel some of the antiquated cases, cutting off the ginger bread and reducing the amount of frame in proportion to the amount of glass, and as fast as his funds permit, he is carrying out this scheme throughout the museum. But more interesting to us in the present connection is the cheapness of the cases which he has had built as a beginning towards those which he in-



Plans for a cheap case.



Working drawings of a more elaborate and expensive case.

tends to have throughout the museum for the housing of instructive and useful exhibits, his idea being that while these cases are not all he would desire, still they serve the purpose so that the public, both old and young, both scientist and layman, may derive benefits from the museum until such time as he has secured funds for ideal cases.

With this inspiration and having in the Rocky Mountains Museum need to build at least one case and install it within three weeks, I designed a cheap case for a small museum or a museum having small funds.

Any ordinary house carpenter can make such a case at an extremely low cost. The materials may be obtained wherever window sashes are to be had. All the woodwork may be cut to sizes at the local mill, and this is especially desirable where a large number of cases are to be made, as it will save much of the expense of the carpenter work.

The kind of wood and molding may be varied according to what is cheapest and most easily obtainable, care being taken, however, if any molding is, used to choose that which is simple, dignified and will not gather dust. It may be desirable to let the size of the glass panels and even of the case depend somewhat on the size of glass that can be obtained.

The advocating of a cheap case, its manufacture, installation and use, in no way militates against advocating the best and most expensive cases on the market, but on the contrary paves the way for them. The museum that waits to be useful until it can have cases costing many hundreds of dollars each will probably wait a long time for financial support. The museum that teaches and otherwise becomes useful to the public with clean, neat, though cheap cases, will gain the sound financial support which it deserves, at least as soon as the present generation of children grow to positions of authority.

One form and size of this case is practically a simple box 5 feet wide over all, with a window sash screwed on as a cover. The sides of the case may be 7/8 stuff, 1 foot wide and 7 feet high. The top and bottom of the same stuff 1 foot wide is set in about 3 inches more or less from the ends of the sides. These four boards constitute the box frame without front or back. A piece 2½ inches wide is nailed across from side to side at the top and bottom of both front and back to strengthen the frame and to cover the space above and below the top and bottom of the case; the lower one also serves as a support upon which the lower edge of the glass front and glass or wooden back frames may rest. This 2½ inch strip only partly covers the edge of the top and bottom, so that the screws holding the front and back may be screwed into the top and bottom, but also so that there may be no crack or space left at the outside of the top and bottom of the case. A kicking molding may then be put across at the bottom, both front and back, but it should not project beyond the ends of the case, as this would prevent several cases being placed (close together) end to end. In short, the ends of the case should be flush. A board is next put over the top of the case to keep dust and rubbish from gathering in the space outside of the case top, and to give the case finish. This board should project an inch or two in front and behind, but as in the case of the kickboard should not extend beyond the ends of the case. A molding may be placed below this top in the corner between it and the 2½ inch strip across the top of the front of the case according to taste. The general label may then be fastened on this molding, on the 2½ inch strip, or from the cover of the case to the 2½ inch strip. In fact one purpose for having the case extend above the top of the exhibition space, that is above the top of the glass sash, is to provide this space for a case label. On the other hand a case label may be painted directly on the 2½ inch strip or the sash.

The front of the case is made of a simple window sash, such as may be obtained in any town where a sash and door factory exists, or for that matter where houses are built. It is fastened with round headed screws engaging the edge of the sides and top of the case, the frame resting upon the 2½ inch strip across the lower part of the case. By screwing the frame on, it is not necessary to go to the expense of hinges and locks. The screw holes may be soaped, waxed, or metal screw sockets may be used if it seems desirable to go to that expense. A screwdriver serves as a key. Moreover, by drawing the screws tight, the case may be made as near dust-proof as is necessary in a small museum. In fact much more fuss is made about dust-proof cases and about getting fine cases than about using them after they are obtained. A little attention given to wiping out cases, cleaning specimens and looking to the upkeep of the specimens in most cases would be cheaper and quicker than giving so much attention to dust and insect proof cases. Moreover, going over the specimens say once a year for such a purpose, the curator could hardly fail to note the lack of order and labels, and many things, which he could then do to improve the usefulness of his exhibit. However, cotton tape or wicking set in a plained groove may be added to exclude dust if desired.

The glass should be in the largest pieces obtainable, up to the full size of the frame, and where more than one piece of glass is required preference should be given to running the mullions horizontally so that they may the more often fall opposite a horizontal shelf edge instead of vertically across the line of vision. It is hardly necessary to say that the glass should be of the best quality which the museum can afford, and certainly should be free from blobs and other blemishes. If it is sufficiently heavy, there will be no need of disfiguring signs requesting visitors not to lean on the glass.

Shelves may be cut about 1/8 of an inch shorter so that they may be moved easily and may rest upon round headed screws or still better on screw eyes turned horizontally, one at each corner of the shelf. When it is necessary to raise or lower the shelf these screws are easily changed and the holes may be puttied up and touched with color, although if left they will no more disfigure the case than the ordinary ratchets used for holding shelves at various heights. The case may be stained or painted with a dull finish, certainly not a very glossy varnish, perhaps preferably with a thin wash, to give it a somewhat neutral color in harmony with that of the walls of the building in which it is to stand.

The back of the case should certainly be put on in the same way as the front, so that if it is ever desirable to turn the case at right angles and have glass upon both front and back, the back may be removed and a glass frame may be put on. If the back is to be solid woodwork which is perhaps desirable where heavy things are to be hung from it, care should be taken that it is built so that the expansion and contraction due to changes in the weather or the heating of the building may not strain the rest of the case. Perhaps as good a way as any would be to let the back of the case be a frame with compo board, as the compo board could be replaced at any time glass was desired. A diaphragm set back against the rear frame would serve for heavy objects and could be covered with burlap or print paper, as desired.

When the case has glass front and back, that is when the exhibit is to be viewed from two sides, or when it is not desirable to use the full depth of the case for the exhibition on hand, a diaphragm about 1/8 of an inch shorter and narrower than the inside of the case may be inserted at any distance from the front of the case, and held in place either with round headed screws through the sides of the case or with small angle irons in front and behind the diaphragm. This method of fastening the diaphragm allows it to be adjusted or removed in a very few minutes with practically no waste and no unsightly scars which could not be retouched with putty and colored.

The cases should be made in uniform sizes or multiple sizes, like sectional book cases, so that they may be moved about and re-assembled, for instance by placing two 3 foot cases side by side to harmonize with a 6 foot case, and so on, or by placing two cases 6 inches deep back to back to approximately harmonize with a case 1 foot deep. Cases should never be fastened to the walls in such a way that when they are moved the room is disfigured, requiring re-plastering or re-painting. A little forethought along these lines will save a large portion of the funds of museums which might be used for other purposes instead of being thrown on the junk heap.

If it is desirable to let light in one or both ends of the case they may be made like the front and back, but then care must be taken that the frame is large enough to hold the screws necessary for supporting any shelves used. If a diaphragm is used, the screws to hold the rear corners of the shelves may be inserted in the diaphragm.

These general plans may be varied, the cases may be made of various heights, widths, and depths. They may be built with higher or lower bases and tops; or again, shorter cases may be built and placed upon tables or pedestals; cases may be super-imposed or hung upon a wall. Very large cases might be made on this same principal, by substituting frames with glass in place of the wooden sides of the cases, it being only necessary in such cases to carry the sides up and down from the top and bottom of the frame in the same manner that the front and back is carried up and down. If the case is so large, as for habitat groups, that it is necessary to have more than one frame, a mullion to which to screw the frames may be inserted between the top and bottom of the case where necessary, but this should not project beyond the sides of the frame. By this means the amount of wood exposed to view is kept at a minimum. If desired, a molding can be screwed over the crack where the frames meet, and if fastened to one of the frames that frame may be taken off first in opening and closing the case, which will save the trouble of unscrewing the molding.

One of the simple forms of these cases, 5 feet wide by 1 foot by 7 feet was made, with the exception of the frame and glass, by two carpenters, during the time which they could take from other work in a single day while assisting in reorganizing the Rocky Mountains Park Museum.

The specifications which have been made by Mr. P. A. Taverner to accompany this description are for a somewhat more complicated and slightly more expensive case, and consequently a number of the dimensions and methods of construction are slightly different.

MATERIAL.

Lumber—All material in case to be of clear, white pine, whitewood or other material most readily obtainable in locality in clear lengths free from large or unsound knots or shakes.

All exposed work may be in oak or other wood to match fittings already installed.

Sash—To be 1 3/8 inch thick of common stock pattern rails and styles 2 inches wide from glass to jamb, and of sizes as shown.

Tops and Ends—May be of 7/8 stuff with 3/8 by 1 3/8 inch rebate along sash jamb or may be built up of two thicknesses of ½ inch stuff. The inner lining being of matched stuff well cramped together and blind nailed

Diaphragm (to be supplied only where desired)—To be of 7/8 inch stuff fastened together with flush end styles well nailed to prevent warping. All should be covered, both sides with burlap or other covering material or paneled according to decoration or other scheme of museum. Diaphragm to be held upright and in place by 1 inch by 1 inch by 1/8 inch iron angles screwed to top and bottom of case on either side of diaphragm. For 3-foot cases there should be two pair of such angles, top and bottom, and for 6-foot cases there should be three such pairs. Diaphragms may be moved to any situation in case by changing position of angles.

Shelves—Shelves for light specimens may be supported by screw eyes inserted in ends and diaphragm or mullions as indicated on drawings, turning them flatways and allowing them to project enough to engage shelves. For heavy specimens, iron brackets—stock sizes, or Shrosbree specimen hangers may be used whenever needed. If a coarse burlap is used over diaphragm, screws may be put in and removed as many times as necessary without causing disfiguring scars on the surface.

Base or Mopboard—To be stock 6 inch base of whatever design may be desired and may be readily obtained at local lumber yard or mill.

Ends—All ends of cases to present perfectly flush surface, so that two or more cases may be butted together to appear as one case without unsightly or dust-catching spaces between.

Cases may be made in units of either 1 or 2 sash. A 1 sash case will then be just half the length of the 2 sash cases and will line up with them in series. The sashes are to be fastened in place by 2½ inch brass, round headed screws, driven through the sash into the frame behind. With this method neither locks or hinges are necessary, and all can be constructed by an ordinary carpenter without special joinery skill.

Glass—To be of sizes shown and of as good quality as procurable. The principal faults to be looked for being color, waves, bubbles or flaws.

Scientific Exploration in Central Asia

From Dr. F. de Filippi the Royal Geographical Society has received a report on the journey of scientific exploration which he has been carrying out between India and Central Asia, under the joint auspicies of the Italian and Indian governments. The expedition has lasted sixteen and a half months, and in that time has accomplished work of the highest scientific importance in Northern Kashmir and Southern Turkestan. The numerous staff included eminent Italian men of science, as well as a party from the Survey of India.

From the point of view of geographical discovery the most interesting result has been the exploration of the eastern section of the giant Karakoram range. Here was found a glacier—named Remo—of unexpected size and importance. It is composed of three large rivers of ice, each about 20 miles in length and from 3 to 5 miles in width, and has an area estimated at over 300 square miles.

The expedition derives its chief importance, however, from the systematic scientific observations which were taken at a series of fourteen stations established between Srinagar and Kashgar. By means of these observations the gravimetric survey made by the Indian Survey Department in the plains of Hindustan has been joined on to the similar Russian survey in Russian Central Asia, and the whole has been connected with the gravimetric survey of Europe.

Regular meteorological and magnetic observations were also taken at the different stations. By arrangement with the Indian Meteorological Department, pilot balloons were sent up simultaneously from the expedition's stations and from a number of the department's permanent stations; and by a comparison of the results it is hoped to obtain valuable information respecting the monsoon winds.—*The London Daily Telegraph.*

The History of Opium*

Facts Concerning One of Our Most Valuable Drugs and its Derivatives

By David I. Macht, A.B., M.D.,[1] Johns Hopkins University

If the entire materia medica at our disposal were limited to the choice and use of only one drug, I am sure that a great many, if not the majority, of us would choose opium, and I am convinced that if we were to select, say half a dozen of the most important drugs in the Pharmacopeia, we should all place opium in the first rank. If we were to inquire, however, into how much the great majority of the medical men know about the history of this wonderful product of plant life, which, when judiciously employed, has proved such a boon to suffering humanity, if we were to ask about the origin of some of our most familiar remedies—laudanum or paregoric, for instance—I fear the information gleaned would be meager. It is doubtful whether it is even generally known that opium, so widely used in China, is not indigenous to that country, but was introduced there at a comparatively late date. This were apology enough for a brief historical sketch on the subject, but a glance at the history of opium and its derivatives from the earliest time to the present may teach us more. If the aim of the history of medicine is not altogether the recitation of interesting anecdotes, but rather to trace the progressive development of our noble art and science, then is the history of no other drug more calculated and better fitted to illustrate the gradual transition from the obscurity and mysticism of the ancient *Dreck-Apotheke* or polypharmacy and kakopharmacy to the rational therapeutics of the present day.[2]

EARLY HISTORY.

The medicinal properties of poppy juice date from a remote period, and yet not so far back in antiquity as we might expect, for the earliest definite and authentic references to it are found only in the Greek and Latin literatures. Of course, recalling the mystic rites and highly developed culture of the ancient Egyptians one is inclined to imagine that the narcotic properties of opium were known to them; but the investigations of Unger (1857) have failed to trace any acquaintance with opium in Ancient Egypt, and Dr. Ember, of the Semitic Department of this university, tells me he knows of no reference to it in Egyptian literature. According to some Hebrew scholars, there is a reference to poppy juice in the Bible. In several passages in the Old Testament the word *rósh* is mentioned in connection with the word *la'anah*, wormwood or absinthe (Jer. viii 14, ix 14, etc.). *Rósh* in these passages is in the authorised version rendered hemlock. *Rósh*, however, in Hebrew is the word for "head," and so it has been taken by later scholars to mean poppy head, and *me-rósh*, or the juice of *rósh*, rendered by Jewish interpreters as "poison water," is taken to mean the juice of the poppy. This interpretation fits well enough in the context, and further support is given it by the fact that the Latin for poppy-heads is *capita*. Prof. Haupt is convinced that *rósh* means the poppy, and so also is Prof. Post, who is considered an authority on the flora of Palestine. In the Talmud we have one reference to opium, under the name *ophion* (Jerusalemic Talmud, Tr. Abodah Zarah, 40a), but that word was clearly borrowed from Greek.

In regard to Sanskrit, Prof. M. Bloomfield of the Sanskrit department of this university tells me that opium is not at home in India, and so in the classical Hindoo literature (Brahmanical, Buddhist, Jinist) there is found no reference to it. From the time of the Mogul Conquest on there appears a word *Khash-khash* which means poppy-seed, and *Khash-khasha-rasa*, juice of the poppy. In this it is easy to recognize our modern word *hashish;* and so it seems that at that early date the narcotics opium and cannabis indica were confused with each other.

In modern Sanskrit lexicons there are found the names *aphena* and *ahi-phena* applied to opium; *aphena* strictly means "foam," and *ahi-phena*, "serpent's foam." As these words for opium do not occur in any literary document, Dr. Bloomfield suspects that they are the English opium "sophisticated by what is known as popular etymology."

The original home of the poppy was in Asia Minor. From there it was carried to Greece at a later period.

The name opium is derived from the Greek ὀπός or "juice." From this word were later formed the Hebrew *ophion* already mentioned, and more particularly the Arabic *af-yun*, which has found its way into other Asiatic languages. The Chinese name for the drug *o-fu-yung* (and its modifications *ya-pien* and *opien*) are not of native origin, but are all derived from the Arabic.

It is not at all certain whether Hippocrates was acquainted with the juice of the poppy. According to Wootton, he refers to a substance called *mecon*, to which he attributes a purgative as well as narcotic action. Some think that it was opium; others believe that he was referring to another plant. In any case, he made but very little use of the drug.

The first authentic reference to the milky juice of the poppy we find by Theophrastus at the beginning of the third century B. C., when he speaks of it as μηκώνιον (meconion).

Scribonius Largus,[3] in his "Compositiones Medicamentorum," about the year 40 of the present era, describes the method of procuring opium from the capsules of the poppy, and about the year 77 of the same century Dioscorides makes a distinction between the juice of the capsules which he called ὀπός and the extract of the whole plant or μηκώνειον, which he regarded as less active. He describes the method of incising the capsules, and refers to adulterations of the drug with the milky juices of other plants, such as Lactuca, so that from his statements it is evident that the collection of opium was quite an industry in Asia Minor at that time. He also describes the preparation of a syrup of poppies or *dia-kodion*, which is the original of the syrup of poppies of the German and other Pharmacopeias to this day.

Pliny devotes some space to a description of opium and its medicinal use, and the drug is mentioned repeatedly as *lacrima papaveris* by Celsus in the first century and by numerous other Latin writers. Galen spoke enthusiastically of the virtues of opium confections, and the drug was soon so popular in Rome that it fell into the hands of shopkeepers and itinerant quacks.

The introduction of the drug to the natives of the East was through the Arabs, and in the first instance to Persia. Its introduction into India seems to have been connected with the spread of Mohammedanism and was favored by the Mohammedan prohibition of wine.

The Arabic physicians used opium very extensively, and even wrote special treatises on some of its preparations. The most celebrated of them, Abu-l-ali-ibn-Sina, more commonly known as Avicenna (980-1037), recommended it especially in diarrhea and diseases of the eye. Avicenna himself is said to have met death from an overdose of the drug. Serapio (about 1080) used it freely, and Maimonides and Averroes each wrote a treatise concerning the theriaca, of which I shall have much more to say a little later.

The earliest mention of opium as a product of India is by the traveler Barbosa, in his description of the Malabar coast in 1511. A Portuguese historian, Pyres, in a letter to Manual, King of Portugal, in 1516, speaks of the opiom of Egypt and Bengal. It is from Egyptian Thebes that we have the terms "opium thebaicum" and the alkaloid thebain.

Opium is supposed to have been brought to China first by the Arabs, who are known to have traded with the southern parts of the empire as early as the ninth century. Later the Chinese began to import the drug in their junks from India. At that time it was used by them exclusively as a remedy for dysentery. It was not before the second half of the eighteenth century that the importation of opium began to increase rapidly through the hands of the Portuguese, and a little later through the famous East India Company. In 1870 the English established an opium depot in Lark's Bay, south of Macao, and the traffic rapidly increased, so that very soon the Chinese authorities began to complain, and in 1820 an edict was issued forbidding any vessel having opium on board to enter the Canton River. A system of contraband followed, then political friction between England and China, and the so-called Opium War, which culminated in the Treaty of Nanking (1842) by which five ports of China were opened to foreign trade, and in 1858 opium was admitted as a legal article of commerce. By that time the vice of opium-smoking had spread like a plague over the gigantic empire, and became so deeply rooted that, in spite of innumerable edicts and decrees, all efforts to check its growth have been powerless. A poor sort of missionary work by the enlightened West among the heathen Orientals!

I shall not spend here any more time in tracing the history of opium in China, or in dwelling on the horrors of the opium habit, with its frightful constipation and even more terrible diarrhea, and the physical and mental degeneracy to which it leads. Our object is rather to follow the use of opiates therapeutically, and in Europe.

Since the time of Galen, the use of opium was continued in a disguised form in various concoctions and confections containing so many ingredients that the distinction between the important and useless could not be discovered, and the value of the drug was overlooked, except by a few brighter minds.

The famous physician of the middle ages, Philippus Aureolus Theophrastus Bombast von Hohenheim, commonly known as Paracelsus (1490-1540), owed much of his success to the bold way in which he administered opium to his patients. He is said to have carried opium in the pommel of his saddle and called it the "stone of immortality." His followers were as enthusiastic as himself over the virtue of opium. Platerus of Basle in 1600 strongly recommended it, and Sylvius de la Boe, a famous Dutch physician, declared that without opium he could not practice. The celebrated chemist and physician Van Helmont, about 1640, used it so frequently that he was called Doctor Opiatus, and Sydenham about 1680 writes that "among the remedies which it has pleased Almighty God to give to man to relieve his sufferings, none is so universal and so efficacious as opium."

THE FOUR OFFICINAL CAPITALS.

No better illustration of the widely beneficent properties of opium and at the same time of the hopeless muddle of superstition, kakopharmacy and polypharmacy pervading the older materia medica and therapeutics, can be given than by a brief description of the four remedies which are sometimes known as the four officinal capitals, of which Wootton,[4] in his "Chronicles of Pharmacy, says, "There were writers who ventured to criticise some of the details of composition, or some of the uses made of these compounds, but the possibility of medicine existing without them was hardly contemplated previous to the eighteenth century." These four standbys or panaceas were the *mithridatium*, *theriaca*, *philonium*, and *diascordium*.

Mithridatium was a confection which derived its name from Mithridates VI or the Great, king of Pontus in Asia Minor, born about the year 134 B. C., who was one of the most troublesome foes the Roman Republic had to deal with. He was finally defeated by Pompey. This personage is said to have been a student of poisons, and was accredited with having invented or concocted an alexipharmac or antidote as a protection against them, which was named mithridatium after him. The legend goes to say that when conquered by the Romans, to escape capture he poisoned his wife and daughters and then took poison himself; but according to the story he had so successfully immunized his body to all sorts of poisons that his efforts at suicide proved unsuccessful and he had to call on one of his soldiers to dispatch him. Hence, the origin of the term "mithridatism" or immunization against the effects of a poison through gradual administration of small doses of it. As the king of Pontus was accredited with having possessed especial skill in the production of medicines, his conqueror, Pompey, took care to ransack his medical writings and secure whatever he could. Thus, whether from Mithridates or not, a panacea bearing his name found its way into Roman literature and became very popular. Various modifications of it were later made, the most important of which was the so-called theriaca.

Theriaca was invented by Andromachus, the physician of Emperor Nero, and was devised as an improvement on mithridatium, which until then was the great antidote of Roman pharmacy. The most important difference between the two was the addition of vipers. The word "theriaca" comes from the Greek θηρίον, wild beast, or serpent, and has reference to its use as an

* From the *Journal of the American Medical Association.*

[1] This sketch is intended to be an introduction to a pharmacologic study of some opium alkaloids carried on by the author and endorsed by a grant from the Council on Pharmacy of the American Medical Association.

[2] In the preparation of this manuscript the following authorities have been frequently consulted: Geissler and Möller: Real Encyclopedie der Gesammten Pharmacie, Leipzig, 1886-1891. Flückiger and Hanbury: Pharmacographia or History of Drugs, 1874. Rice: New Remedies, 1876, p. 229. Jones, John: The Mysteries of Opium Revealed, London, 1701. Guareschi: Einführung in das Studium der Alkaloide, Berlin, 1896. Thompson, C. J. S.: The Mystery and Romance of Alchemy and Pharmacy, 1892. Jeffreys and Maxwell: Diseases of China, 1900.

[3] Largus, Scribonius: De Compositione Medicamentorum, 1786.

[4] Wootton: Chronicles of Pharmacy, 1910.

antidote against snake bites. According to Galen, the virtues of this panacea were the following:

"It resists poison and venomous bites, cures inveterate headache, vertigo, deafness, epilepsy, apoplexy, dimness of sight, loss of voice, asthma, coughs of all kinds, spitting of blood, tightness of breath, colic, the iliac poison, jaundice, hardness of the spleen, stone, urinary complaints, fevers, dropsies, leprosies, the troubles to which women are subject, melancholy, and all pestilences."

Though all this may seem a huge joke, all these virtues were accepted down to the seventeenth century, and many learned treatises were written on the subject. For some centuries various cities, such as Constantinople, Cairo, Genoa, and Venice, gained the enviable reputation of manufacturing the most efficient theriaca. Later Venice overshadowed them all; and the Venice theriaca, or as the word became corrupted, Venice *treacle*, was for a long time famous, and is found in the London Pharmacopeia as late as 1745. Our present word "treacle" is derived from this confection; in earlier English works, however, treacle signified much more than molasses, and was used metaphorically for the divinest blessings.

I am now going to quote the ingredients of theriaca, as given by Galen, first to illustrate the curious conglomeration of an enormous number of useless drugs, and secondly to point to the presence in it of opium, to which probably a great part of its virtues was due. The ingredients of this, as well as of mithridatium, were given in Greek verse, in order that they might be better remembered.

ELECTUARIUM THERIACALE MAGNUM.

"Root of Florentine iris, licorice, 12 ounces each; of Arabian costus, Pontic rhubarb, cinquefoil, 6 ounces each; of Ligusticum meum, rhubarb, gentian, 4 ounces each; of birthwort, 2 ounces; herb of scordium, 12 ounces; of lemon grass, horehound, dittany of Crete, calamint, 6 ounces each; of pennyroyal, ground pine, germander, 4 ounces each; leaves of laurus cassia, 4 ounces; flowers of red roses, 12 ounces; of lavender, 6 ounces; of St. John's wort, 4 ounces; of lesser centaury, 2 ounces; saffron, 2 ounces; fruit of amyris opobalsamum, 4 ounces; cinnamon, 12 ounces; cassia lignea and spikenard, 6 ounces each; Celtic nard, 4 ounces; long pepper, 24 ounces; black pepper and ginger, 6 ounces; each; cardamoms, 4 ounces; rape seeds, agaric, 12 ounces each; seeds of Macedonian parsley, 6 ounces; of anise, fennel, cress, seseli, thlaspi, amomum, sandwort, 4 ounces each; of carrot, 2 ounces; *opium*, 24 ounces; opobalsamum, 12 ounces; myrrh, olibanum, turpentine, 6 ounces each; storax, gum arabic, sagapenum, 4 ounces each; asphaltum, opoponax, galbanum, 2 ounces each; juice of acacia and of hypocist, 4 ounces each; castor, 2 ounces; Lemnian bole, calcined vitriol, 4 ounces each; trochiscs of squill, 48 ounces; of vipers, of sweet flag, 24 ounces each.

"Triturate the balsams, resins and gums in a sufficient quantity of wine to form a thin paste, and incorporate the whole with 960 ounces of honey."

Philonium was another famous antidote, invented by Philon of Tarsus, who is supposed to have lived in the early part of the first century of the present era. It is conjectured from an obscure passage in Pliny that this antidote was prescribed against an epidemic of colic or dysentery which occurred in Rome in Philon's time. Philonium was the original of the confection of opium which remained in the English pharmacopeias until 1867. In the Pharmacopei Londinensis of 1746, the ingredients of philonium are given as follows: white pepper, ginger, caraway seeds; strained opium, and syrup of poppies, the proportion of opium being 1 grain in 36 grains of the confection.

Diascordium, the last of the four officinal capitals, was a medicinal compilation by Hieronymus Fracastorius, a famous physician and poet of Verona in the early part of the sixteenth century, and is given in his book "De Contagio et Morbis Contagiosis." It was originally devised as a preventive of the plague. In the eighteenth century it became a popular household opiate and was frequently given to children for soothing purposes. The original formula, which was adopted in the first London Pharmacopeia in its integrity, mentioned among its principal ingredients cinnamon, cassia wood, scordium, dittany, galbanum, storax, gum arabic, *opium*, sorrel, gentian, Armenian bole, Lemnian earth, pepper, ginger, and honey. Later some of the ingredients were dropped, and the Edinburgh Pharmacopeia made it more astringent by adding catechu and kino. The mangled remains of this famous panacea are represented by the British and U. S. P. Pulvis Catechu Compositus, and Pulvis Kino Compositus.

LATER USES OF OPIUM.

The compound powders of catechu and kino just mentioned are not the only relics of ancient opium compounds remaining in the British and our own pharmacopeias. The commonest pharmaceutic preparations of opium still in use are of antique extraction, and it may be of interest to devote a few words to them at this place.

Our tincture of opium or laudanum dates from Paracelsus (1490-1541). Paracelsus probably applied the name "laudanum" to several medicines, all of which contained opium. This one historian describes a *pill mass* which he designated as laudanum of Paracelsus, and which consisted of one fourth of its weight opium, to which were added henbane juice, mummy, salts of pearls and corals, bone of the heart of a stag, bezoar stone, amber, musk, and essential oils.

Another laudanum, known as anodynum specificum of Paracelsus, was obtained by digesting opium, with orange and lemon juice, frog's sperm water, cinnamon, cloves, ambergris, and saffron. So much for the more ancient laudanum. The laudanum of the early London pharmacopeias was a pill mass, made of a mixture of opium, wine, saffron, castorum, diambrae, ambergris, musk, and oil of nutmeg. The principal liquid preparation of opium used in England a little later was the so-called Sydenham's laudanum. The formula was given by Sydenham in his work on dysentery in 1669-1672, and called for the following ingredients: strained opium, saffron, cinnamon, clover, and canary wine. About the same time, that is, at the end of the seventeenth century, another preparation known as Rousseau's laudanum was much in vogue on the Continent. This differed from the other laudanum in being a fermented compound, and was named after a Capuchin monk by the name of Rousseau. This holy man was sent from Rome to Paris to learn medicine preparatory to mission work in Asia, but became enamored with the subject and settled in Paris to practice the art of healing. He became a favorite with Colbert, the minister of Louis XIV; rooms and laboratory were provided for him in the Louvre, and Louis ordered the Faculty of Medicine to give him a degree.

The name "laudanum," attributed to Paracelsus, is supposed to be derived from the Latin "*laudandum*," "something to be praised." According to some philologists it is related to gum labdanum or ladanum, from which a stomachic cordial was prepared in the middle ages. Others regard it as an abbreviation of the two words *laudatum opium*. Still others endeavor to find in it a corruption of the word *anodynum* with the article prefix, that is, *l'anodynum*, or *the* anodyne, and some latter day punsters humorously refer to it in bad Latin *Lauda non!* "do not praise," which conveys more truth than poetry.

In the early part of the eighteenth century another celebrated opiate was the so-called "black-drop." Its inventor was one Edward Runstall of Auckland, and it was also known as Lancaster or Quaker's black drop. A formula for its preparation was as follows: Opium, ½ pound; verjuice, 4 pints; nutmegs, 1½ ounces; saffron, ¼ ounce. Boil, add two spoonfuls of yeast, and set in a warm place for six to eight weeks; then decant, filter, and put in bottles. This preparation was three times as strong as laudanum, and is the forebear of the English Acetum Opii.

Our other familiar friend and popular household anodyne, paregoric, originated with the elixir asthmaticum of Le Mort, professor of chemistry at the University of Leyden from 1702 to 1718. A modification of Le Mort's formula given in the London Pharmacopeia of 1721 was as follows: honey and licorice root, of each, 4 ounces; flowers of benjamin and opium, of each, 1 drachm; camphor, 2 scruples; oil of aniseed, ½ drachm; salt of tartar, 1 ounce; spirit of wine, 2 pounds. In the London Pharmacopeia of 1746, the name of it was changed to Elixir Paregoricum. In that of 1888 the official name became Tinctura Opii Camphorata. This preparation was also known as Tinctura Camphorae Co., and in the German Pharmacopeia as Tincture Opii Benzoica. The word "Paregoric" comes from the Greek παρηγορικός, which means "soothing" or "consoling."

Our official opium pills, or Pilulae Opii, are not a modern product, but are descended from the old English Pilulae Saponis Company, or Pilulae Saponaceae, which in their turn are an adaptation of the long famous nostrum known as Matthew's Pills or Starkey's Pills. Starkey was a physician who invented them, and Matthew was a vender who sold them. The pills consisted of opium, soap of tartar, and a number of other trivial ingredients.

No account of the history of our opiates can be said to be complete without a reference to Dover's powder, and its originator, the adventurer and knight errant of English medicine, Thomas Dover. I shall not dwell long on the life of this interesting individual, especially as an account of him by Osler[a] has already been published. Born at Barton on the Heath in Warwickshire in 1660, he studied medicine, and in his youth lived at the house of the famous Thomas Sydenham. Many have probably read of how he later joined a privateering party, and led a life of adventure, roaming around the world; how the ship in which he was sailing rescued Alexander Selkirk, the man who lived alone on an island for over four years and who became the prototype of the famous Robinson Crusoe. When he returned to London and settled down to practice, Dover[b] wrote his "Ancient Physician's Legacy to His Country." In this work, in the chapter on gout, he gives the recipe for his "diaphoretic powder" in the following words:

"Take opium, 1 ounce; saltpeter and tartar vitriolated, each 4 ounces; licorice, 1 ounce; ipecacuanha, 1 ounce. Put the saltpeter and tartar into a red hot mortar, stirring till they have done flaming. Then powder very fine. After that, slice in your opium; grind to a powder and mix. Dose, from 40 to 60 or 70 grains in a glass of white wine posset, going to bed, covering up warm, and drinking a quart or three pints of the posset while sweating. In two or three hours at furthest the patient will be free from pain."

This will suffice for the commoner opium preparations.

THE ALKALOIDS.

Let us now turn from this region of pharmaceutic romance, superstition and mysticism, to some of the achievements that characterize the pharmacy of the nineteenth century, and which mark the beginning of rational therapeutics.

As is well known, throughout the middle ages it was the great ideal of all chemists, or rather alchemists and pharmacists, to search after essences, or quintessences of things, after the philosopher's stone, the elixir of life, etc., and it is natural to find that of all popular drugs opium should be the one especially tortured to give up its essence. Therefore the various laudanums and extracts of opium, and preparations known as magisteria opii, were products of activity exerted in that direction.

Toward the end of the eighteenth century it was a universal belief that plants could elaborate products of only an acid or neutral nature, and that alkalies were substances of a very different character, related more to the metals and exhibiting metallic properties. It was not until the beginning of the nineteenth century, with the discovery of the alkaloids, that this conception was shattered, and it is significant that the first alkaloid to be discovered was the chief active principle of opium—morphin. The honor of this epoch-making discovery belongs to a German, Friedrich Wilhelm Adam Sertürner. Sertürner was born July 19th, 1783, in Paderborn. He became an apothecary and chemist at Einbeck in Hanover, Germany, where he did his most important work, and moved later to Hameln, where he died, February 20th, 1841.

Sertürner began his investigations of opium in 1803, and published the first report of his studies in 1805, when he announced his discovery in opium of an acid, *Opium-Saure*, which he later named "meconic acid," and which he explained was combined with an alkaline base which he called morphium. In a second communication, in 1816, he gave a detailed account of his work, and described the chemical as well as the pharmacologic properties of morphin, which he tested out on himself, and came near losing his life.

"I flatter myself," he wrote, "that chemists and physicians will find that my observations have explained to a considerable extent the constitution of opium, and that I have enriched chemistry with a new acid (meconic) and with a new alkaline base (morphium), a remarkable substance which shows much analogy with ammonia." Sertürner's discovery excited so much interest, and its importance was regarded as so great, that in 1831 the Institute of France awarded to him a prize of 2,000 francs "for having opened the way to important medical discoveries."

Next in importance to morphin in point of quantity, the opium alkaloid narcotin was discovered really before morphin, in 1803, by the French pharmacist Derosne, who obtained crystals of what proved to be narcotin while diluting a sirupy aqueous extract of opium. These crystals became known as *sel d'opium* of Derosne. The basic or alkaloidal character of the body, however, was not established until 1817 by Robiquet, another pioneer in alkaloidal chemistry. The same Robiquet was the discoverer of the next very important opium alkaloid named codein, in 1832. The discoverer of the next opium alkaloid was another illustrious chemist, Joseph Pelletier, whose name is familiar to us from the active principle of male fern, pelletierin. Pelletier was born in Paris in 1788, and died there in 1842. A son of an apothecary, he was from his earliest days engaged in chemical and pharmaceutic studies, and later became a director of the school of pharmacy in Paris. He was the first to isolate a large number of alkaloids. In 1832 he discovered the opium alkaloids narcein and oxymorphin, and in 1835, with Thiboumery, another alkaloid, thebain.

[a] Osler, W.: Bull. Johns Hopkins Hosp., 1896, vii, 1.

[b] Dover, Thomas, M.B.: The ancient Physician's Legacy to His Country, London, 1762.

Pelletier was also the discoverer of strychnin, and together with Caventou, of brucin, quinin, and chinchonin, together with Magendie of the at present interesting emetin, together with Corriol of aricin, together with Thiboumery of pseudomorphin, together with Couerbe of picrotoxin, and together with Pelleton of berberin. Since his time opium has become a nidus for a large number of alkaloids, and promises to yield a few more. Up to the present, according to Winterstein and Trier,[1] opium has yielded besides protein bodies, sugar, gum, resin, salts, and organic acids, twenty-two different alkaloids of which the following is a list: morphin by Sertürner in 1804; narcotin by Robriquet in 1817; codein by Robriquet and narcein by Pelletier in 1832; thebain and pseudomorphin by Pelletier and Thiboumery in 1835; papaverin by Merck in 1848; cryptopin in 1857; gnoscopin in 1878 and xanthalin in 1893 by T. and H. Smith; codamin, laudanin, meconidin, and lanthopin by Hesse in 1870; laudanosin and hydrocotarnin in 1871, and protopin in 1872, also by the same investigator; oxynarcotin, by Beckett and Wright in 1875; tritopin by Kauder in 1890; laudanidin by Hesse in 1894; and last, pseudopapaverin and papaveramin by the same man in 1903.

Besides the primary opium alkaloids, a large number of derivatives of them have been made, which we need not enumerate here. Let me but mention apomorphin, apocodein, heroin, dionin, and peronin.

All these chemical individuals have been analysed, their empiric formulas established, and an attempt, at least in case of some of them, has been more or less successfully made to determine their structure. Along with this chemical work, which forms one of the most brilliant chapters of modern chemistry, a great deal, though by no means complete or sufficient, physiologic and pharmacologic work has been done with them.

Only within the last few years, the work of Straub, Faust, Bürgi, Sahli, and others has marked a still further step in our knowledge of their therapeutic properties. These authors have shown that not only have the various opium alkaloids individually definite pharmacologic actions, but that also still other effects can be produced by combining them with each other.

Thus, if we trace the history of opium from its earliest beginnings to the brilliant researches of recent years, if we but compare the analytic and synthetic, chemical, physiologic, and pharmacologic studies of the same old drug with the fantastic and puerile effusions on the subject of our medical predecessors, we cannot help being impressed with the long strides forward which medicine has made; yet, on the other hand, our very recent studies on opium and its alkaloids serve but to emphasize the more our meager knowledge of the subject and the still greater task before us.

Coal Substitutes*

Use of Chalk Fuel and Peat Proposed in England

If coal remain at a prohibitive price it cannot be expected that, after their present contracts have run out, the suppliers of gas and electricity will continue to let us have these essentials at the old price. Already, in certain industries, it is being found cheaper to use some other source of power than coal, and this is a tendency that will increase as long as the price of coal is rising and that of gas and electricity remains stationary. It is a tendency, however, deserving of every encouragement, for the consumption of coal in small quantities is often a wasteful proceeding, and we ought as a nation to do everything we can to economise fuel, so as to have no shortage when the time of great industrial expansion arrives after the war.

It was stated some months ago before the war that "the internal combustion engine is the power agent of the future, and it will be a problem of no mean dimensions to provide the very large supplies of fuel which we must have if we are to hold our own in the world's markets." The reference was largely to liquid fuels, but we have to consider also the internal combustion engine which derives its energy not only from petroleum, its allied products, or even from alcohol, but from producer-gas. In this latter case anthracite has been a necessity heretofore.

Some recent experiments would seem to suggest that there may be available in this country suitable substitutes not only for anthracite in gas-producers, but also for coal generally, even for domestic purposes.

One of these substitutes consists of a mixture of chalk, rough small refuse coal, and solidified tar, in the proportions, respectively, of about 60, 30, and 10 per cent, the mixture being compressed into ovoids or pieces about the size of a large plum. This chalk-fuel, as it may be termed, burns freely, when once combustion is started, in an open grate or under a boiler, and is quite smokeless.

* The London Daily Telegraph.

[1] Winterstein and Trier. Die Alkaloide, Berlin, 1910.

The idea of using crude chalk in the grate alongside with coal is not a new one, and it is often claimed that economy of coal results in this way, which is quite possible seeing that chemical action proceeds when chalk is heated, this chalk giving up some of its oxygen to form carbon-monoxide, and lime being left behind as ash. But the addition of the above-mentioned carbonaceous substances to the chalk naturally increases both its heating value and freedom of combustion, and the resulting chalk-fuel is expected to be a useful fuel in the future, especially as destructor refuse can be worked in as one of the materials composing the compressed ovoid. This is a valuable feature, as many towns spend as much as 10s. per ton to get rid of their refuse.

The materials required are so cheap that it would seem to be possible to produce this fuel at about half the normal price of coal, at any rate on the South Coast, where chalk is plentiful and coal expensive.

From an engineering point of view, the experiments in power production that have been made on a gas-producer plant are instructive. This particular plant ran two gas engines of 80 brake horse-power each, and supplied gas (equivalent to 10 horse-power) to lacquering ovens. Using bituminous coal, the fuel consumption was 23 hundredweight per twelve hour day, as compared with 17 hundredweight of chalk-fuel for the same period. As might be imagined, the gas from the latter was much cleaner than that produced from anthracite or coke. The lower fuel consumption meant that stoking was not so frequent, and consequently a saving of labor could be effected; further, there was no clinkering.

An interesting point in the running of the engines was that much more air could be admitted to the mixing chamber than was the case with ordinary gas; in fact, the air-valve could be worked fully open. This rather bears out the assumption that an unusual amount of carbon monoxide gas was formed (from the disintegrating chalk, which afterward falls to the bottom of the producer as lime), and this would, of course, need an extra amount of air for efficient combustion, and would explain why less fuel was required to give the same amount of power. The flames arising from the gas when burnt in the lacquering ovens were also very hot, as they would be from a gas rich in carbon monoxide. The latter gas, it was shown by analysis, was present to the extent of 18 per cent, other constituents being carbon dioxide, 10 per cent; hydrogen, 7 per cent; marsh gas, 4 per cent; and nitrogen, 61 per cent.

The fuel itself, when analysed, was found to consist of fixed carbon, 28.45 per cent; volatile matter (including water), 26.95 per cent; and ash, 44.6 per cent. It should be possible to use it in locomotives, and, as there is also the prospect of the use of gas-producers on shipboard for driving internal combustion engines, we may yet see the chalk cliffs of old England becoming a diminishing quantity in order that England's ships may put out to sea.

A second substitute for coal in this country is peat, of which there are vast quantities in Ireland, Wales, Scotland, and also in many parts of England.

A great amount of work has been done in the direction of employing peat as a fuel, especially in Canada and the United States, where peat fuel is in regular use in place of coal, and it has been shown that, besides being useful for domestic purposes, peat can be used under boilers or in gas-producers. Peat dust formed into briquettes with 5 per cent of coal dust has been successfully used in locomotives drawing trains weighing from 218 to 200 tons, the consumption of peat fuel being just twice as great as was the case when coal alone was used.

That the use of peat for driving gas engines is not now a mere experiment is clear from the success of the recently established Weismoor electric generating station in East Friesland, where the total supply per annum of energy for lighting and power is now almost 10,000,000 kilowatt-hours, all derived from peat-consuming gas-producers.

A smaller but similar British plant has been found to give very much more satisfactory results with peat than with coal after the separation of tar from the gas had been effected by means of an ample water spray for cooling and washing the gases, the tar being thrown out by a centrifugal tar extractor. The plant can be run for three weeks without cleaning, and the saving in cost between running the factory on coal and on peat amounts, when peat is employed, to over £15 per week.

The Canadian Department of Mines has had a series of peat-fuel tests made on a Körting gas engine at the Ottawa Fuel Testing Station, which show that the fuel consumption per brake horse-power hour—including stand-by losses—is for full load, 1.7 pound of peat, or 2.3 pounds of peat containing 25 per cent moisture; for three quarter load the corresponding figures are 2.1 pounds and 2.8 pounds. Assuming that peat can be delivered to the plant at 8s. 6d. per ton, and that the plant be run with a power factor of 75 per cent for 3,000 hours, the fuel costs would be 30s. per brake horse-power year, including stand-by losses.

Peat fuel is expected to have a big future, not only in this country, but in Canada, Russia, and other countries possessing large peat deposits. Russia alone has more peat than all the other countries of the world, and it has been calculated that its average selling price in Russia should be about 9s. 6d. per ton. There would thus appear to be a useful opening for British engineers to develop a new branch of industry—the supply of the necessary gas engines and gas-producers for use with peat fuel.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, MAY 29th, 1915

Published weekly by Munn & Company, Incorporated

Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876)	per year	$5.00
Scientific American (established 1845)	"	3.00
American Homes and Gardens	"	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

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VOLUME LXXIX NUMBER 2057

NEW YORK, JUNE 5, 1915

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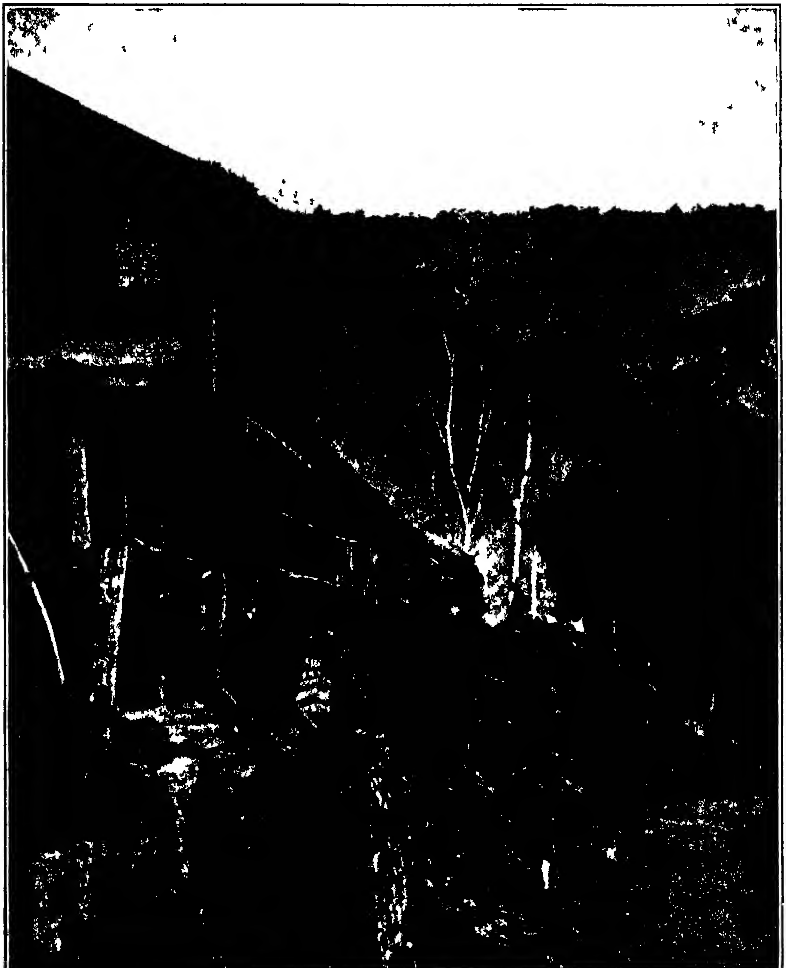


A native village in the hill country of India.

INACCESSIBLE NEPAL, ON THE BORDERS OF INDIA.—[See page 357.]

Patents and Their Purpose

Notes of Historic Interest

By Jeremiah Lee MacAuliffe

The history of industrial arts is the history of patents. The patent laws exist because of the cold fact that in no other practical way can public knowledge of new inventions be obtained. An invention, being at first possessed by the inventor alone, may remain his secret. If the nature of the invention permits, it may be made profitable to him by remaining his secret, and without advancing the public interests, or increasing the sum total of man's knowledge. The grant of patents, therefore, has this all-sufficient justification—it is a means by which the inventor can be induced to impart his secrets to the world at large.

INDUSTRIAL GRANTS AND PATENTS FOR INVENTION.

Originally, patents granting exclusive manufacturing privileges were not confined to inventors. They were granted to those introducing a new industry into a country, and especially is this true of England, though patents of the kind had previously been granted to some limited extent at least, on the continent of Europe. Earlier monopolies by Greek and Roman merchants, without authority from government, are referred to by Robinson in his very comprehensive and scholarly work on patents.

INVENTION.

By a comparison with the earlier grants, the character of letters patent of to-day is more clearly seen, as well as the gradual approach to the requirement of "invention" which now is universally a condition precedent to the grant of a valid patent.

Very early the importance of industrial development was realized. We are told by Schlosser that Alexander the Great made a determined effort to gather a knowledge of the inventions of all nations, and to disseminate this knowledge among his own people and those subjugated by him, *with a view to promote contentment and prosperity*. Other interesting examples abound in antiquity and in the middle ages.

INSTANCES OF DISCOURAGEMENT.

Exceptions to the general encouragement of inventors are recorded, noteworthy being the refusal by Queen Elizabeth (1589) to grant a patent for the knitting machine to its inventor, William Lee, M.A., of Cambridge (Knight's Mechanical Dictionary). More modern instances of a hostile attitude will be readily recalled in the doubts originally expressed as to the benefits, to labor and to society at large, to be obtained from the sewing machine. Another instance is that of the riotous actions of wood sawyers and carpenters, whose obliquity of vision led them to violent opposition to the introduction of the power sawmill and planer in the United States, and in Great Britain and Ireland, and made them feel contentment with even the lot of the "bottom sawyer," rather than to accept the promised improvement in conditions to be brought about by the new machines.

Industrial corporations flourished in Flanders, in France, Germany and in England, probably reaching their greatest power in Germany, where many of the free cities were formed into the Hanseatic League, in the thirteenth century. In these "free cities," which date from about the tenth century, it had been the custom to class the citizens in companies according to their occupations. The Hanseatic League enjoyed special privileges in return for services to the monarchs in whose realms it operated. The manufacturing corporations of Flanders at this period are also thought to have been at least temporarily dependent on the encouragement of the ruling sovereigns.

PATENTS FOR INVENTIONS ALONE SURVIVE.

For a long period the industrial development on the continent of Europe was far in advance of that found in England, and the latter exported little of manufactured goods except woolens. The industries of the continent, however, showed little indication of original investigation, and no marked progress in mechanics. England, awakening eventually to her backwardness, took steps looking to the establishment of new industries within her borders. She early invited foreigners, skilled in the different arts, to locate and establish manufactories in England; and finally she particularly recognized inventors as proper recipients of patents. Some of the grants recorded were mere letters of protection to foreigners settling in England. Others, even some of those to inventors, are to be noted as including only the exclusive right to manufacture, thus leaving open the right of importation and sale. It is worth mention that this medieval form of grant was substantially retained in the patent grants of Denmark as late as 1894, when a new law went into effect.

The issue of *Engineering* for June 22nd, 1894, calls attention to the fact that a vital feature of the modern patent, to wit, the general prohibition against the public other than the patentee, characterized grants of Elizabeth, and apparently the issue of the general prohibition was in response to a petition by an Italian inventor, one Acontius, in 1559, who urged this as a necessary part of the reward to the inventor. It has been suggested that Acontius was perhaps acquainted with the existence of similar monopolies on the continent. Another essential of the modern patent, the specification disclosing the invention, also characterized patents issued under Elizabeth, such a patent having been granted as early as 1561 for the manufacture of saltpeter. The first patent specification *accompanied by drawings* appears to be the British patent, No. 169, of 1673.

PURPOSE OF INSTRUCTING THE PEOPLE.

To revert to the early forms of grants, the letters of protection granted by Edward III, in 1331, to Johannes Kempe, of Flanders, to establish the manufacture of textiles in England, are perhaps notable in that they are granted avowedly for the purpose of *instructing the people* in a new industry. (Flanders at this time made higher grades of woolens than the English). The grantee obligated himself to teach all seeking a knowledge of his calling.

Almost in exact line with the purpose of this grant are the modern patent rights of all nations, as will later appear. The Kempe grant is not otherwise notable, however, since an industrial patent or grant, earlier by nearly two centuries, was given, according to Hallam, to the Weavers Company by Henry II.

The first systematic effort to establish manufactories in England by granting patents, was made in 1337 (*Law Quarterly Review* for April, 1896), when a general statute was passed, placing under the King's protection the cloth workers of other lands who came to dwell in England, "to the intent that said cloth workers shall have the greater will to come and dwell here, our Sovereign Lord the King will grant them franchises *as many and such as may suffice them*."

If we are still interested in comparing forms of governmental encouragement of industry, we may take note of a significant incident having some relevancy to the subject, as related by Hume, who explains that an attempt to foster commerce and trade by encouragement from the Crown, was made in England by Athelstan (925-941): "He passed a remarkable law which was calculated for the encouragement of commerce, and which required some liberality of mind in that age to have devised; that a merchant who made three voyages beyond the sea on his own account should be known as a thane or gentleman."

What appears to have been the first patent for an alleged *new invention*, was granted in 1440 in England for new process of making salt. In a patent given to one George Bobham for an improved dredging machine, the object of the grant is made clear. It expressed the wish of Elizabeth that the favor thus accorded the patentee "will give courage to her subjects to study and seek for the knowledge of like new engines and devices." The granting of few patents in England, and the absence of material results, prior to the Elizabethan era, are accounted for by two causes, to wit: internecine wars, and the practical nullification of the patent statute during several successive reigns, when the skilled foreigners were invited *into the service of the Crown* instead of receiving franchises for the benefit of public manufactures.

INVENTORS ALONE ENTITLED TO PATENTS.

From 1600 the abuse of the privileges enjoyed by the holders of industrial monopolies resulted in the unmistakable public call for confining the grant of patents to inventors only, but promises of reform by Elizabeth quieted for a time the agitation against public monopolies. Finally, the dissatisfaction aroused by the gross abuses of the companies who controlled trade, culminated in 1623 under James I, and the noted statute against monopolies was passed. The English public, even when thus aroused over the wrongs suffered under the general monopolies, did not lose sight of the benefits to be derived by the public from encouraging inventors, and the very statute of repeal of monopolies specially recognized the propriety of granting exclusive rights to the inventors of new manufactures to enjoy their inventions *for a limited period of time*.

Much confusion exists among students of the patent laws regarding the statute of James I. This did not create any rights for inventors, nor grant them anything which they did not previously enjoy, but merely was in keeping with the decisions of the English courts, which, whenever occasion had arisen, had endorsed the validity of grants to inventors, while condemning industrial monopolies granted to others.

The patents granted under the statute of James did not as a rule *afford a disclosure of the invention*, and some British patents as late as 1750 contained merely the title. Moreover, under this statute of James, an invention was held to be patentable if it were not previously known in England; and it was of no moment that the invention was known and published in other countries.

The patent grant to-day the world over is like the Kempe grant of six centuries ago, in that one obligation is inexorably imposed and one condition exacted, the instruction of the public. The law requires a *bona fide* disclosure; and proof of a violation by the withholding of essential particulars invalidates the patent, as a contract void for the absence of a valuable consideration.

EARLIEST AMERICAN PATENTS.

The first patent issued in this country was granted by the General Court of Massachusetts Bay Colony, in October, 1641, to one Samuel Winslow, for a new method of manufacturing salt. In recurring to this Winslow patent, and to the first patent ever issued for a new invention (1440), both for the manufacture of salt, we are strikingly reminded that patents for inventions are dictated by no mere sentiment, but by considerations of public welfare—even public necessity—which originally prompted in England, and later in this country, the granting of patents for new inventions in order to encourage and increase the production of this most important article. The term of the Winslow patent was ten years, and the grant was conditional upon Winslow's setting up works within one year. Several other patents were granted by the Bay Colony and other colonies in the same century. It appears that Massachusetts, Connecticut, and Pennsylvania were the principal members of the original colonies which granted patents.

The articles of confederation, adopted July 12th, 1778, contained no authority to grant patents; but the States issued them independently, as the three colonies above mentioned had done. Thus, in 1785, James Rumsey obtained special grants or patents from the States of Maryland, Virginia, Pennsylvania, and New York, for a "newly invented boat," which was practically tested on the "Potowmack" (Potomac) in September, 1784, in the presence of George Washington, who gave the inventor a letter highly commending the boat as "of vast importance in inland navigation." John Fitch, Rumsey's more successful rival and contestant, also received, at about the same time, similar patents, or exclusive privileges, from New York, Virginia, and Pennsylvania.

RECOGNITION OF INVENTORS RIGHTS—OBLIGATION OF GOVERNMENT.

The Constitution of the United States made provision for the encouragement of inventors, and in 1790 a patent statute was passed by the Congress. To the constitutional convention belongs the credit of, for the first time, embodying in the law of a nation the fundamental doctrine that an invention belongs by inherent right to the inventor, *and that to secure this right to him, with due regard to public interests, is an obligation of Government*. In 1836 the Patent Office was established, and provision made for the examination of inventions to determine their novelty, this being the first instance of such a provision in patent laws. The present laws are substantially those passed in 1870, which extended the term of the patent from fourteen to seventeen years, and prohibited extensions except by special act of Congress.

The proposition to give cash awards to inventors and throw the inventions at once open to the public gained some favor in Great Britain in 1869, but the proponents were silenced when reminded that the experiment had actually been tried more than a century before, and with ill success. A rather diverting item, showing some of the results of this experiment appeared in the Scientific American for September 18th, 1869. Inventions of real merit seemed, for some reason, to remain a secret under this cash plan.

Cash grants are not unknown in the United States. Thus Joshua Shaw, who in 1814 invented the percussion cap, was debarred from receiving a patent because he was an alien, but later the Government awarded him

$25,000 (SCIENTIFIC AMERICAN, August 7th, 1869). Also, in France, Daguerre and Niepce, in 1839, were granted annuities in recognition of their invention of photography, that could not adequately be protected by patent (Tissandier's History of Photography).

PROPOSITIONS TO REPEAL PATENT LAWS.

During the sessions of the sixty-third Congress, discussion of the patent laws became widespread, attention having been focussed on the subject by the introduction of the "Oldfield Bill," which proposed compulsory licenses. There were those who, not content with the suggestion of compulsory licenses, advocated the complete repeal of the patent laws. The reader may consult a report issued by the Cleveland, Ohio, Chamber of Commerce, 1913, for an admirable, critical study of the Oldfield bill, with a discussion of the patent system of the United States.

Bearing on the suggestions of repeal, the reader will be interested in an illuminating incident involving a similar proposal. In 1869 it was actually proposed in England to repeal the patent laws (see issues of SCIENTIFIC AMERICAN during September, 1869). The agitation to this end had its origin in an attempt by the millers to avoid payment of royalty to the inventor of an improvement which prevented the wasteful and unhealthful clouds of dust that theretofore were incidental to the use of millstones. The repeal was opposed by various bodies, including the Workingmen's Technical Education Committee, The Foremen Engineers' Association, The Workingmen's Club and Institute Union, The Public Museums and Free Libraries Association, and various workingmen's organizations. These not only opposed repeal, but demanded a more liberal patent law, which would give a patent as a matter of right, and for a reasonable fee. The patent laws of England at that time made patents very costly, and were productive of outrageous delays. An excerpt from an argument at this time is instructive:

"Mr. C. W. Siemens, F.R.S., a native of Prussia, left that country and came to reside in England, because practically no encouragement was accorded to inventors in Prussia. Mr. Siemens' regenerative furnaces and improvements in telegraphy had augmented our national wealth to the extent of several million pounds sterling, all of which was lost to Prussia through it having practically no patent laws." This policy has been reversed by the Germany of to-day. Siemens himself later delivered an address (SCIENTIFIC AMERICAN, October 16th, 1869) in which he said: "If we review the progress of the technical arts of our time we may trace important inventions almost without exception to the Patent Office. In cases where the inventor of a machine or process happened to belong to a nation without an efficient patent law, we find that he readily transferred the scene of his activity to the country offering him the greatest encouragement, there to swell the ranks of intelligent workers."

WHAT OF THE PATENT OFFICE?

Dickens, in his scathing exposure of the circumlocution office, with its staff from the ancient family of Barnacles, has shown that a very bad patent law can be made infinitely worse when administered with the purpose, How not to do it. In "Little Dorrit" we see the inventor, Daniel Doyce, of the firm of Doyce & Clennam, iron works.

"As an ingenious man, he had necessarily to encounter every discouragement that the ruling powers for a length of time had been able by any means to put in the way of this class of culprits; but that was only reasonable self-defense in the powers, since How to do it must obviously be regarded as the natural and mortal enemy of How not to do it. In this was to be found the basis of the wise system, by tooth and nail upheld by the circumlocution office, of warning every ingenious British subject to be ingenious at his peril; of harassing him, obstructing him, inviting robbers (by making his remedy uncertain, difficult and expensive), to plunder him, and at the best, of confiscating his property after a short term of enjoyment, as though invention were on a parallel with felony."

If a bad law can thus be made worse, so also, a good law can be made better, by officials motived by How to do it. The United States Patent Office organization is dominated by the commissioner, the examination of applications being done by a corps of examiners separately in charge of approximately fifty different divisions. The corps includes first, second and third assistant examiners. Official actions of the examiners are checked up (when appealed) by the Board of Examiners in Chief, and the Commissioner.

When, in the war of 1812, the keeper of patents in Washington placed himself in front of the British guns trained upon his office, determined himself to be destroyed if the threatened destruction of his precious records was to be carried out, he established the standard by which Commissioners of Patents have generally elected to be measured, so that we see men of national repute as patent lawyers exchange a very lucrative private law practice, for the honors of the commissionership.

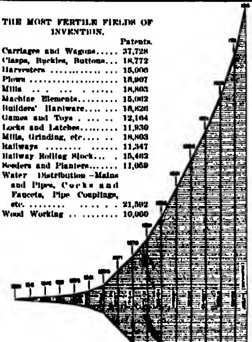
The successive commissioners find at their service a body of examiners whose duties and jurisdiction are strictly defined by the statute and the official rules, but wherein, owing to the nature of the task, the personal equation may nevertheless become a factor beyond the power of law or rule to determine. Skilled in the sciences and in mechanics, learned in the law and practiced in its impartial application, the examiners judge and rule upon (subject to appeal) the questions, largely controversial, arising as to patentability and related matters, in the tens of thousands of cases annually presented—cases not infrequently calling for what, by any applied test, must be regarded as learning of a high order.

GUARDING PUBLIC INTERESTS IN THE PATENT OFFICE.

When Doyce became disheartened, after twelve years' effort to obtain a patent at the Circumlocution Office, and his junior member took up the unequal struggle, no vaticination could have foretold the voluntary action of American applicants in holding applications pending for twelve years and half of twelve more, by dilatory

THE MOST FERTILE FIELDS OF INVENTION.

	Patents.
Carriages and Wagons	37,728
Clasps, Buckles, Buttons	18,772
Harvesters	15,000
Plows	18,907
Mills	18,803
Machine Elements	15,012
Builders' Hardware	18,820
Games and Toys	12,164
Locks and Latches	11,930
Mills, Grinding, etc.	18,803
Railways	11,347
Railway Rolling Stock	15,462
Seeders and Planters	11,059
Water Distribution—Mains and Pipes, Cocks and Faucets, Pipe Couplings, etc.	21,502
Wood Working	10,000



	Patents.
Locks and Latches	11,930
Washing Machines and Other Laundry Appliances.	11,385
Buckles, Buttons and Clasps	18,772
Steam Engines	11,907

SOME OF THE MOST PROLIFIC INVENTORS.

	Patents.
Edison	977
Elihu Thomson	617
Francis H. Richards	847
Edward Weston	299
Charles E. Scribner	437
George Westinghouse	340

Diagram showing ratio of increase of United States patents for each five years.

tactics, until it suited their purpose to have the patent issue. This wrongful practice has been effectively eliminated by a forceful commissioner, and we have, in his action, but one instance only of many, wherein the officials guard the public interests while handing out even justice to inventors.

A practitioner of forty years before the Patent Office recently said to the writer, that amid the mass of mechanical, scientific and legal technique, by statute bound up with the daily activities of the Patent Office, quite generally he has found there, splendidly exemplified, the human element and the spirit of helpfulness.

As a striking example of efficiency and sturdy integrity in free government, the service modestly rendered each workday in the United States Patent Office, should be known and be heartening to earnest men everywhere.

RESULTS EXPRESSED IN NUMBERS.

As perhaps a not inappropriate conclusion, a diagram is appended, showing graphically the increasing number of patents granted, and consequently inventions disclosed in the Patent Office, during what must ever remain a wonderfully interesting epoch in our industrial development. This diagram covers the eighty years from the establishment of the Patent Office, 1836 to 1915.

A public disclosure of nearly one and one quarter million new inventions in eighty years will be conceded a fair return made by inventors for the very limited rights which they have enjoyed. Besides, there is a surplus of many millions of dollars accumulated in the United States Treasury, for the credit of the Patent Office, from fees paid in by applicants for patents.

Engineers' Difficulties With Tropical Telephones

TELEPHONE troubles are far from rare in England, says *The London Daily Telegraph*, but they are mild in comparison with those that occur in the tropics. British users of the 'phone should be thankful that the engineers of the home system have only an occasional gale or snowstorm to contend with; their plight would be very sad if instead of these comparatively rare disturbances, they had frequently to meet such obstacles to the satisfactory working of the telephone as are enumerated by Mr. W. Llewellen Preece in his most interesting paper read recently before the Institution of Electrical Engineers on "Telephone Troubles in the Tropics."

It appears that the troubles in the tropics arise from such causes as damp, vegetation, animals and insects, and inefficient native labor. The heat is in itself not responsible for much trouble, but when this is combined with an atmospheric humidity varying between 80 and 90 per cent it is possible to appreciate the reasons for the telephone engineer's complaints. When, in addition, it is realized that this damp heat produces a marvelous growth of vegetation—so thick that along the sides of the country roads there are actual walls of green leaves, perhaps 80 feet to 100 feet in height, so dense that it is impossible to pierce through without getting one's clothes torn off the body, and growing so rapidly that it may be cut back one day and grow as high again in the ensuing twenty-four hours; when again it is learned that insect life is as prolific as the vegetation, and sometimes even more trying, then one is in a position to understand the difficulties and to sympathize with the tropical engineers.

As a matter of fact, these are not the only troubles. Lightning has a virulence unknown there. The electrical state of the atmosphere has an effect on the human nerves which seriously disturbs one's temper. Even wild animals do their best in some places to increase the engineer's labors. For instance, in some parts it is not unusual to have a mile or two of lines wrecked by giraffes, elephants, or monkeys.

As regard insects, Mr. Preece has some remarkable facts to bring forward. These creatures will attack both instruments and lines. The spider is a real pest all over the tropics: it delights to retreat into the telephone case, and there build for itself a nest, so that it is no uncommon experience to find instruments entirely put out of action owing to the diligent work of this insect.

To circumvent the insect plague it is essential that these telephone cases should be sealed up as closely as possible. The switch-hook should carry a brass plate which keeps the slot in which the arm works entirely covered. It is also desirable to have no terminals above the instruments, but to take the conductors through holes into the case and seal up these holes.

The prevalence of white ants makes it hopeless to use wood poles to carry the lines, as in a very few years the insects demolish the whole of the interior of such poles. The arms, on the other hand, are often made of this material, for the white ant will not work its way up fifteen or more feet of iron tube to reach these arms, and in some countries most excellent hard wood is obtainable locally. The normal type of overhead construction now employed in most tropical countries is fairly well standardized. The poles used are either of a type with wrought iron upper tubes and cast-iron bases, or of the Hamilton type, which are built up of tubes of riveted sheet steel.

Overhead line troubles would, of course, be abolished if underground cables were used, but when it is a frequent occurrence for some subscribers to be situated as far as twenty-five miles from the exchange this system would call for such a high subscription as to make the proposal entirely prohibitive.

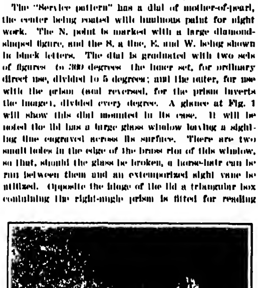
Thus the use of overhead lines must be confined and means devised to make them less likely to be attacked by insects. It has been discovered that whereas insects will nest in porcelain insulators which are dark inside—they refuse to inhabit the transparent glass insulators, which, if made of the oil type, should, it is suggested by Mr. Preece, bring about considerable improvement in the insulation. Unfortunately, such insulators are not at present commercially obtainable.

The Prismatic Compass*

How It Works and Some of Its Advantages

The prismatic compass is so called from the prism fitted on the case at the opposite side to the hinge. By means of this prism an observer is enabled to read the figures on the dial when taking a bearing.

The "Service pattern" has a dial of mother-of-pearl, the center being coated with luminous paint for night work. The N. point is marked with a large diamond-shaped figure, and the S. a line, E. and W. being shown in black letters. The dial is graduated with two sets of figures to 360 degrees the inner set, for ordinary direct use, divided to 5 degrees; and the outer, for use with the prism (and reversed, for the prism inverts the image), divided every degree. A glance at Fig. 1 will show this dial mounted in its case. It will be noted the lid has a large glass window having a sighting line engraved across its surface. There are two small holes in the edge of the brass rim of this window, so that, should the glass be broken, a horse-hair can be run between them and an extemporized sight vane be utilized. Opposite the hinge of the lid a triangular box containing the right-angle prism is fitted for reading



The prismatic compass (mark VI).

the dial. Over the dial a glass is placed in a revolving bezel. On the glass is painted a black "index" line corresponding with an engraved line on the bezel working over a graduated scale on the outer surface of the box. By this line and scale a bearing can be "registered" for night marching operations.

In taking a bearing, the compass is held steadily, raised to the eye, keeping it quite level, and the front sight (*A* in small diagram shown in Fig. 5—line on glass) and the back sight (*B* -slit on the prism box) are aligned on to the objective *O*. The division seen in the prism cut by the hair line *A* will be the bearing required.

The bearing can now be registered by turning the milled edge bezel until the black index line on glass is over the N. point of dial. The division on the top scale of outside of box which coincides with line is the bearing. At the same time, the direction is indicated by the compass letters on the bottom scale. The bezel is then clamped. On any subsequent occasion, day or night, the same direction can be found by turning the cover back flat (as in Fig. 2), holding the compass in front of you until the N. point on dial coincides with index line. The sighting line on glass and luminous patches in cover point to the objective.

It is not always possible to ascertain the bearing by sight, so the compass is then set by means of a map. This is done by ruling a line through the point of departure to mark the *magnetic* N. and S. line, and a second one to the objective, to mark the line of advance (see Fig. 3)—Departure, London; objective, Godalming).

The compass is laid along the one showing advance, and carefully adjusted by laying the sight of lid and bow ring at back over the line. The index is now shifted until it exactly coincides with the N. and S. line. The compass is then ready for use.

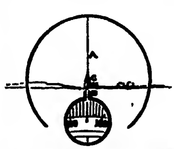


Fig. 5.—What the observer sees in the prism-box of a prismatic compass.

This diagram shows in the smaller circle what the observer might see in taking a bearing, holding the instrument as in Fig. 1 The larger circle represents diagrammatically the window. *A*, front sight on window; *B*, back sight slit in prism-box; *O*, distant objective.

The Value of Birds to Man

Among the zoological articles in the Smithsonian Annual Report is one on the value of birds to man, in which the author, Mr. James Buckland, of London, makes the astounding statement that, although man imagines himself the dominant power of the earth, he is nothing of the sort, the true lords of the universe being the insects. For although man has attained predominance over the most fierce and powerful animals and most deadly reptiles, he and his works would be of little avail before an attack of insects, which include a greater number of species than all other living creatures combined. Some 300,000 species have been described, while possibly twice that number still remain unknown.

The author says that these incomputable hordes feed on nearly all living animals and practically all plants, and multiply into prodigious numbers in an incredibly short time. Computations show that one species developing 13 generations a year, would if unchecked to the twelfth generation, multiply to 10 sextillions of individuals; while a single pair of the well-known gypsy moths, if unchecked, would produce in 8 years enough progeny to destroy all the foliage of the United States. One pair of potato bugs, he states, would develop unchecked 60,000,000 in a single season, at which rate of multiplication the potato plant would not long survive.

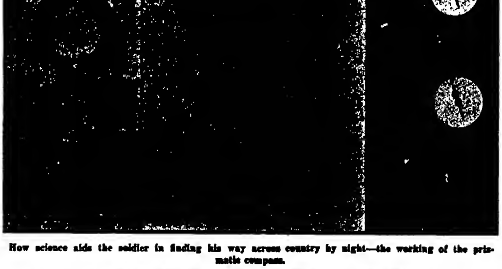
According to Mr. Buckland's article, insects are quite as astounding in their consuming qualities as in their rate of increase; a caterpillar eats twice its weight in leaves a day, and, in proportion, a horse would consume a ton of hay in 24 hours. Certain flesh-eating larvae consume 200 times their original weight in 24 hours; in this manner an infant would devour 1,500 pounds of meat during the first day of its life. It is reported by a specialist, that the food taken by a silk-worm in 56 days equals 86,000 times its original weight. All of which facts show what tremendous destruction insects may cause.

Through its predominating insect diet, and on account of its exceedingly rapid digestion, the bird becomes the most indispensible balancing force of nature; without its assistance, man, with his poisons, the weather, and animals, as well as the parasitic predaceous insects, would be helpless. The author then states how the bird is a benefit to man in a great number of ways; in checking insect invasions, in preserving forests and orchards; their service in the meadows and gardens; their value in protecting live stock, and their usefulness in the preservation of health and elimination of disease.

Remarkable instances of the birds' service to man include the introduction of the English sparrow into New Zealand with the resulting elimination of the thistle and the caterpillar which were ruining the land and crops, and the saving of Australian agriculture from the grasshoppers by the straw-necked ibis, in individual craws of which an average of 2,400 grasshoppers was found. The story of Frederick the Great, wherein he is alleged to have ordered all small birds killed because the sparrows had pecked at some of his cherries, and the resulting lack of fruit but fine crop of caterpillars two years later, proves a graphic lesson. The "Scalp Act" of Pennsylvania, which paid in bounties $90,000 for the extermination of hawks and owls, lost for the State $3,850,000 in damage to agriculture due to the increase of small rodents which resulted. When Montana was free from hawks and owls it became so overrun with destructive rodents, that the legislature offered rewards for them—a task which the banished hawks and owls had performed free of charge. But during the first six months such large sums of money were paid out that a special session of the legislature was called to repeal the act before the State went bankrupt.

In closing, Mr. Buckland makes a plea for the preservation of all birds as a valuable natural resource, stating that if their destruction is not checked, there will be wrought a mischief, a universal disaster, greater than words can express.

The Italian Aerological Service, which has been in operation since May, 1912, probably represents the most thoroughgoing attempt that has yet been made to maintain a daily survey of the direction and force of the air currents at various levels over an area of national extent. As compared with the analogous German service (*Wetterdienst für Luftfahrer*), which has 21 stations, the Italian service has, in a smaller area, 31, and has thus far published the results of observations on a much more extensive scale. The latest undertaking of the Italian service is a daily bulletin, with charts, showing the winds at various levels over Italy, as observed at 8 A. M. and 3 P. M. by means of pilot balloons and nephoscopes. The service has also published detailed discussions of the observations, which bring out many interesting facts regarding the air circulation at various levels in connection with barometric conditions at the surface. The director of this aeronautical weather bureau (which appears to be entirely independent of the regular meteorological service of Italy) is Capt. Luigi Matteuzzi.



How science aids the soldier in finding his way across country by night—the working of the prismatic compass.

These diagrams should be studied in connection with the article opposite on the prismatic compass. Here it may be added, in continuation of that article, that before the night-march takes place the dial is exposed to daylight (about half an hour before sunset should make it luminous for some six to nine hours). The compass is then used exactly as with a registered bearing (Fig. 4), the sighting-line and luminous patches pointing to the line of advance—Godalming. In the latest form of compass exposure to daylight is unnecessary, as the wonderful substance, radium, has provided us with a new radioactive paint that is always self-luminous. The compass-needle, of course, points to the magnetic north, and not the true or geographical pole. The variation in England is some 15 degrees.

* From *The Illustrated War News*, published by *The Illustrated London News*.

Nepal*

Notes on a Visit to a Country Inaccessible to Europeans

By Henry John Elwes, F.R.S.

NEPAL is unique in this respect, that it remains a solitary instance in the world, of a friendly country which, from political reasons alone, is inaccessible to Europeans. For, though during nearly a century our relations with its rulers have been perfectly peaceful, and latterly even cordial, and though the present ruler of Nepal is a man of European culture, speaking perfect English, and understanding English customs, politics and civilisation in a way that few Oriental rulers do, he has rigidly adhered to the policy instituted sixty years ago by the all-powerful minister, Jung Bahadur, and has maintained a system of government which may be best described as a paternal despotism founded on the religion and customs of his people. It is, therefore, impossible for Europeans even to enter Nepal unless specially invited, as we were, by the British Resident at Katmandu, Colonel Manners-Smith, V.C., or by the Maharaja Sir Chandra Shamsher Jung, G.C.B., G.C.S.I., G.C.V.O., to both of whom our most cordial thanks are due for their hospitality and kindness during our too short stay there.

Though our relations with the Nepalese government were not at first so uniformly friendly as they have been ever since the Indian mutiny, when Jung Bahadur came to our assistance with his army, yet we have learned that it is possible to do what has never been done by any other European government—to live as neighbors on a frontier of over five hundred miles without any friction with an Oriental nation distinguished for the bravery and patriotism of its people. And after comparing the conditions which exist in the kingdom of to-day with the state of some parts of Bengal in recent times, I think that we can learn much from the Nepalese in the art of governing primitive mountain races. I will refer those who wish to know more of the country to Sir W. W. Hunter's "Life of Brian Hodgson" (1896), who resided in Nepal as British Resident for many years, and who was the first to make known to science a great number of its animals and birds; or to the "Imperial Gazetteer of India," Vol. XIX. (1908), where an excellent account of the country will be found.

We arrived at Gorakhpur, in the United Provinces, on February 6th, and met Colonel Manners-Smith, who had kindly invited us to join him in camp at Bikna Thori, on the Nepal frontier, to see a kheddah which had been arranged to take place near the locality where King George had such grand tiger shooting when he was in India for his coronation. We arrived at the frontier by rail, and rode up to a camp in the low outer range of hills which inclose a flat, and in some places marshy valley, a little higher than the Terai. The usual system of catching elephants in Nepal differs from that adopted in other parts of India which I am about to describe, and is much more dangerous both to the pursuers and the pursued. It consists of driving the wild elephants into a valley where they can be surrounded, and then, after separating those which it is intended to catch from the herd, overpowering them by special fighting elephants and tying them up separately. In these fights many of the elephants are injured, and fatal accidents to the men employed are not uncommon. But on this occasion the Nepalese government had determined to try the system of kheddahs usually adopted in Assam and Southern India by the Indian government, and had obtained the services of Mr. Armstrong of the Bengal police, and of some of the skilled elephant catchers formerly employed by the government kheddah department at Dacca, which has now been disbanded. This valley and the hills surrounding it are of much the same character as the Dehra Dun, and are covered on the dryer land with forest, mainly composed of sal and other trees often of much larger dimensions than those in the Dehra Dun or in the Sikkim Terai, and in the open and more marshy parts by a heavy grass jungle, which forms a sanctuary for wild elephants, tigers, rhinoceroses, and other game which are preserved for use and sport. At this season the country is dry, cool and healthy, but in the rainy season very hot and malarious. The next day we rode on to the large camp which had been formed for the men employed in the elephant-catching operations on the banks of a river, and found that a considerable number of wild elephants had already been surrounded in a piece of forest about four miles in circumference, bounded on the south by the outer range of hills, on the west by a river whose bed was now partly dry and open, and partly covered by grass and reeds high enough to conceal elephants. The force employed to effect this surrounding consisted of two regiments of Nepalese soldiers directed by the general-in-chief of the Nepalese army. After the wild elephants, about thirty in number, had been surrounded, a line of guards was immediately stationed at posts fifteen to twenty yards apart all round the forest. At each of these posts three soldiers were on guard, who built themselves grass huts, and kept fires burning all night falling gate on one side, suspended by ropes which were cut to let it drop. From the entrance a narrow lane of strong posts extended for two hundred yards, gradually widening into two wings, which opened out like a funnel, and were extended by a line of cloths hung on poles, to form a lead into the mouth of the alley. The walls of the stockade and the lane leading to it were covered by grass and branches so that the elephants might not suspect danger too soon. During

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A herd of wild elephants penned in a stockade.

to keep the wild elephants from breaking out. Our camp was on the low banks of a river overlooking the scene of operations and close behind the guardline. The first thing to do was to select a position for and build a stockade into which the elephants could be driven, and in this matter the old Jemadar from Dacca, a veteran of seventy years who had spent his life in this work, was the best adviser. He insisted in going alone on foot into the ring where tigers and rhinoceroses were known to be at large with the wild herd, in order to choose the most suitable place. For long experience has shown that wild elephants cannot be driven like cattle, and it became evident, from the frequent attempts which they made at night to break out in a particular direction, where was the best place to build the stockade. This took three days of hard work, as a large number of strong posts fifteen feet long by eight to ten inches in diameter had to be fixed in the ground and supported by struts and cross-bars strong enough to resist the pressure of the herd when driven in. The stockade was a circular space fifty feet across, with a

the four nights that we were in camp waiting for the stockade to be built, there were constant alarms at various points on the line, as the wild herd, after drinking in the river—where we could often see their backs and hear their trumpeting and screams from our tents—made efforts to find a weak spot in the guard line. On the second night a wild tusker, supposed to be a rogue, broke into the surrounded area from the outside, and made the inclosed herd very uneasy. This tusker was very bold, and one night, just after dinner, he came down and stood within twenty yards of the fires where a crowd of excited men were yelling and firing blank charges in his face, and we quite expected that he would attack and break out. But though we saw him quite close in the moonlight, he eventually retired and the camp became quiet again. On February 12th, after several alarms in the course of the night, which must have been a trying and anxious one for the guards, who had now been for four consecutive days on duty, Mr. Armstrong announced that all was ready, and that about eleven o'clock, when the elephants

* Journal of the Royal Society of Arts.

were generally quietest, the drive would take place. Two platforms had been erected above the stockade into which we climbed, and the driving-party, under the command of Armstrong and the old Jemadar, were mustered. The Nepalese were selected from the most experienced jungle men, and between every two of them one of the Dacca men accustomed to this work was placed. Absolute silence was ordered at the stockade when the party marched off in two lines, which spread out from the stockade and swept the whole of the forest within the guard-line, and when the leaders met on the far side, perhaps a mile away from the stockade, gradually closed in toward it. After waiting an hour or so we heard a great noise accompanied by many shots from the guard-line, which told us that the elephants were on the move, and the noise came nearer and nearer till we thought that the herd must be within the wings of the stockade; but after a time the noise died down, and for an hour nothing more was heard. The same thing happened again, and at last Armstrong came back to the stockade, very hot from his exertions, and told us that the Nepalese drivers were so excited and keen that he could not keep them in order, and that on the first occasion the elephants were on the point of entering the wings but were so frightened by the noise that they broke back. After a consultation it was decided, on the advice of the Jemadar, to remove the cloth screens to another position where the grass was thicker and wait a bit before trying another drive. This was done, and about 5 P. M. a final and successful effort was made. The elephants came on within the screens, and then Armstrong and his men lit grass fires behind them, and by dint of firing and yelling got them on the move toward the alley, into which an old cow first came rushing down. The others followed her, and as soon as they were all within the wider part of the alley the crowd of men yelling and firing rushed them forward in a long line. We could only see their backs as they came down the alley one after another and entered the stockade with a rush. The rope which held up the gate was cut a little too soon, shutting out one or two of the hindmost elephants, but these were determined to follow their companions and forced their way through the gate, which was so hung as to push inward. The whole herd was then inside, and until it was dark they continued to go around and round in a dense crowd, while the men who surrounded the stockade prodded their trunks with spears or fired blank cartridges in their faces when any of the larger ones tried to force their way through. It was very curious to see the way in which the youngest elephants, of which there were three only a few months old, managed to save themselves from being trodden down, by keeping between their mothers' forelegs, and the care which their dams took to protect them. As it was then too late to begin to tie up the animals, we left the stockade at dark to the care of the guards who had now left their posts and come to the stockade. Next morning we returned to see the process of roping and leading out the elephants; but though several of the finest and strongest tuskers were brought into the inclosure the mahouts seemed unused to the work they now had to do in such a dense crowd of elephants. There was not room enough for the noosers to go in on foot, and the constant movement of the crowd surging round and round made it very difficult to get nooses on their feet from the outside. This work requires experience which the Nepalese had not previously had, and from the pictures, which were taken at a kheddah in Southern India where they have more experience in noosing in a stockade, it seems that they are there more adept in what seems a most dangerous work. But though the mahouts had spears with which the prick the trunks of any wild ones which might attempt to touch them, I never saw one offer to do so. Many of the captured elephants now seemed to act very tired and thirsty—as well they might be after such days and nights as they had endured—and we never thought the young ones would have survived; but though it took three days before the whole thirty-three elephants were finally tied up and pulled out of the inclosure, not one was seriously hurt, though several of the oldest were released as not being worth the trouble of training. I will not occupy your time any longer with an account of this process, which has been well described by Sanderson and others. But though native mahouts, who have spent their lives among elephants and have inherited from their fathers a knowledge of their management in health and in sickness which few, if any, Europeans have ever acquired, I believe that a lover of animals who would pay the same attention to elephants that many Englishmen do to horses would learn a great deal which would be valuable in managing the elephants which are still indispensable in the forests of India, and might be even more useful in some parts of Africa.

Ten days later we arrived at Raxaul, a frontier station a little to the east of Bikna Thori, where the Resident has a bungalow, and where he had made arrangements for our journey to Katmandu. The first stage of thirty miles through the level plain of the Terai we made in doolies carried by bearers, and at daylight we found ourselves in the Sal forest near Churia, where the outer range of hills begins. Here we breakfasted and went on horseback over a low rocky sandstone range in which *Pinus longifolia* is a noticeable but not important tree; and passing through a narrow gorge, where in many places the dry river-bed is the only road, sometimes impassable in the rainy season, we crossed an open valley where the cotton trees, *Bombax malabricum*, were of great size. One of which was 120 feet high by 30 feet in girth at 5 feet from the ground, and about 60 feet round the buttresses at ground level.

We then followed the banks of a river along a road practicable for bullock carts and wooded with tropical trees, but not nearly so luxuriant or so varied in its vegetation as a valley in Sikkim of similar elevation would have been. The large white blooms of a shrubby climber called *Beaumontia* were at this season the only striking flowers I saw, and along the road there were but few birds to be seen, as numbers of bullock carts were constantly passing. In the evening we reached Bhimphedi, a large village at the foot of a steep range of mountains over which the path is quite impracticable except for coolies; and here we were met by a party of men with doolies and torches, who surpassed all the bearers I have ever seen in their power. For to carry a man of my weight in the dark up a winding path on a gradient of thirty to forty-five degrees and covered with rolling stones was a work I should hardly have thought possible till I experienced it; and they only stopped for a few moments to relieve each other on an ascent of over 2,000 feet. Near the top of this mountain, the Resident has another bungalow at Sisagarhi, between five and six thousand feet above the sea, where we found dinner and beds ready. Next morning we had a fine view over the outer hills, and found rhododendrons in flower and evergreen oaks all around us on the dry grassy hillsides, reminding me far more of Chakrata in the Northwest Himalaya than of anything in Sikkim. Next morning we went on with the same doolies, and after crossing the ridge at about 7,000 feet descended on foot by a very steep rocky path through a fairly thick forest on the north side, where, though some orchids appeared on the trees and climbing plants and ferns were numerous, the whole aspect of the vegetation was utterly unlike the much damper forest at similar elevations in Sikkim. At the foot of this mountain we found ponies kindly sent by the Maharaja, and turned northwest up an open dry valley, cultivated in places with wheat and mustard as winter crops in small terraced and irrigated fields, and passed over bare grassy downs on which a plantation of *Pinus excelsa* had been made. The villagers' houses were built of brick and roofed with tiles, mostly two-storied, the upper floor being inhabited by the people, and the lower used for cattle and stores. A small primrose, *Primula Munroei*, a Polygonum like *P. vaccinifolium*, and a small stemless *Tragopogon* were the first signs of spring. Crowds of Hindu pilgrims on their way from the plains of India to a religious festival at Katmandu were on the road, nearly all walking, but a few riding or carried on coolies' backs. Among them were large numbers of women, who caused my companion, new to India, to remark that this was the only country he had ever seen where it was possible to pass thousands of women without a smile on the face of one of them. The contrast between their resigned and melancholy expression and the smiling faces of the Nepalese women, who crowd the bazaar and as porters welcome the stranger on his arrival at Darjeeling, is very striking. In the afternoon we ascend another steep ridge through forest mainly of evergreen oak, and at the top had our first view of the great open valley of Katmandu with the snowy mountains in the background. The great open valley terraced and cultivated wherever possible, with the city of Katmandu in the middle of it, and bare mountains covered with brown grass and scrub on the south exposure, formed a scene which, though beautiful in itself, was so unlike and so very inferior in grandeur to the scenery of Sikkim that I could hardly believe I was only two hundred miles to the west of that enchanting country.

Pilgrims, and coolies carrying immense burdens of ironware and European goods on the way to the valley, crowded the path; while those returning were mostly laden with coarse dirty wool from the interior. The last descent was so steep and difficult that a horse-dealer bringing horses from Kabul had some trouble in getting them down. At the bottom we found a good road and a well-appointed pair-horse carriage waiting to take us to the Residency, where we were hospitably received by Colonel Manners-Smith.

It is difficult, if not impossible, for anyone who does not speak fluently the language of a country he visits, and who has no opportunity of conversing freely with the people in their own language, to form a correct opinion of the economic or social condition of its inhabitants, especially when restricted to a very small area surrounding the capital. But after many years of travel in Asiatic countries, including Asia Minor, Siberia, Japan, Formosa, China, Java, the Malay Peninsula, and with an intimate knowledge of Sikkim and other parts of India dating back to 1870, I formed the opinion that the government of Nepal is a form of government well suited to the ideas of Oriental peoples. Though the rulers of Nepal have rigidly kept their country free from European education and commerce, and have strictly adhered to the tenets of their own religion and customs, yet the facts that the people appear healthy, happy, and not over-taxed, that the standing army is one of which any Oriental state may be proud, and that law and order prevail to an extent which has kept the relations of their people and ours peaceable and friendly for a very long period, prove that such a form of government has advantages which modern reformers cannot overlook. And when the internal condition of Nepal is compared with what it was in Brian Hodgson's time, when bloody quarrels among the ruling chiefs and members of the Royal Family were common, one must admit that for a country where the land suitable for cultivation is insufficient for the maintenance of an increasing population, and where the natural products offer few openings for trade or manufactures, Nepal is in many respects fortunate. I cannot help remarking the difference which exists in the friendly relations between British officers, soldiers and tea planters, and their Nepalese soldiers, comrades, and laborers, with the attitude and comparative want of sympathy between Europeans and most other natives of India. One cannot work long with Nepalese without acquiring a respect and liking for their pluck, endurance and cheery goodwill under conditions of danger and hardship; or ignore the devotion they show to Englishmen who treat them properly and understand their ways. As pioneers on the northeast frontier of India they have no rivals, and though there is much difference between the various castes and tribes, yet, on the average, I prefer them to any other natives of India with whom I have had to do. The fact that we are able to recruit and maintain no less than twenty battalions of the best native infantry in India entirely drawn from Nepal, and that the laborers employed in the large and important tea industry of British Sikkim have been almost entirely supplied by Nepalese immigration, proves the importance to British India of our friendly relations with Nepal.

The Maharaja has done much to improve the native breeds of cattle, and has imported from India and Europe bulls of various breeds with this object. He is also trying to improve the sheep with rams from my own flock. The native sheep are a large coarse wooled breed, similar to those kept by the Nepalese on the frontier of Sikkim and commonly brought to Darjeeling for mutton, and are able to endure the cold and wet climate of the higher ranges better than the improved breeds in England would probably do; but below, about 6,000 or 7,000 feet, it is not a country generally suited to sheep, though goats are numerous.

Buffaloes are kept in large numbers in the Terai, and are valued for their milk and meat, but do not seem to be used for agriculture as much as in Formosa, where on steep hillsides, lying with a slope of twenty to forty degrees, narrow irrigated terraces are ploughed by buffaloes, which are much more active and better climbers than their normal habitat would lead one to suppose.

In Nepal, as in Sikkim, most of the cultivation is done by hand labor, and irrigation is general wherever water can be brought. In the dry weather it was impossible to judge of the crops, but the rice and maize stubble did not indicate such good soil as in Sikkim; and I believe that the area of land available for cultivation at healthy elevations is in most parts of the country too small to allow much increase in the population, who emigrate in increasing numbers to Sikkim and the frontier districts of Assam.

Both sexes from their childhood acquire the habit of carrying very heavy loads on their backs, especially the tribes of the higher levels, who carry on nearly all the trade between Nepal and Tibet in loads of from 80 to 200 pounds over paths that would be impassable to beasts of burden.

The forests of Nepal do not seem to have received from the government anything like the attention they deserve, as the growing scarcity of timber in Bengal and the United Provinces must make them valuable in future if they were properly protected. Neither tea nor camphor, both of which would no doubt grow as well as they do in Sikkim, are grown, though I believe that camphor might become a valuable and profitable product.

Whether the necessity for increased revenue to pay for the many kinds of European goods which the government and upper classes are acquiring in larger quan-

tities, will eventually induce the government to pay more attention to trade and industry than they have done at present is a problem that time alone can solve; but up till now no permission has been given to any foreigners to embark on such enterprise—Nepal for the Nepalese being the fixed policy of the past and present rulers.

Of the natural history of Nepal I can say little from personal observation, because we were not able to visit the mountains of the interior, where are found a great variety of birds and animals which have been described many years ago by Hodgson, who, during his long residence, employed native collectors to procure, and native artists to draw, all that he could get. In this way most of the rarer animals which inhabit the central Himalaya were first made known to science, but of their distribution little is known. There are a number of genera represented in the northwest Himalaya by species different from those which are found in Sikkim and Bhutan, and it would be very interesting to know where these species meet, and whether they overlap and interbreed. But the mountains nearest to the valley, where alone the Resident and his friends are allowed to go, are too low, and so little virgin forest remains, that their fauna and flora are much poorer than those of Kumaon, Garhwal and Sikkim. In the Maharaja's grounds at Katmandu we saw three living deer which had been caught on the frontier of Tibet and of which little is known to Europeans. One I believe to be a female of the species known as *Cervus Wallichii*, of which a fine male, now in the Zoological Gardens, was presented by the Maharaja to King George when in India four years ago. Another is a male of *Cervus affinis*, which inhabits the high forest country in the northwest of Bhutan, and whose antlers are sometimes brought by natives to Darjeeling, where it is known as the Shou. The third is *Cervus Thoroldi* = *C. albirostris*, discovered by Dr. Thorold in the country northeast of Lhasa and not known to be a native of Nepal.

In the Maharaja's palace, which is a large modern building in European style, I specially admired the very delicate carving which is done by native carvers in a wood known as Dar, *Böhmeria rugulosa*, Wall.; this is a very close-grained red wood, easy to work, and found along the lower hills, but not usually attaining a large size. The immense quantity of fine woodcarving, with which the older houses of Katmandu are adorned, shows the talent of the Newars in this branch of art, which, however, seems to be a dying if not a dead industry, as there are now no professional carvers except those employed by the Maharaja, and no shops where such beautiful work can be procured. The same seems to be true of the workers in copper, brass and silver, who now work only to order, and I cannot help thinking that these arts might be encouraged by making an outlet for their work in British India, where there is now a good demand among tourists and residents for the fine metal work brought from Lhasa, much of which is similar in character to that of Nepal.

To most travelers the buildings, temples and ancient monuments of the towns of Katmandu and Bhatgaon are probably the greatest attraction in Nepal, as their architecture is unique.

We must remember that although at the present day Buddhism and Brahmanism both obtain in Nepal, where the two are indeed inextricably confused, it was not always so. When the Buddha made his first converts in the Himalayas, five hundred years or so before the Christian Era, he found Brahmanism the established religion of Nepal. Therefore, just as birds, under the memory of the species for a once warm home, go northward with the spring into Arctic lands, so these poor Hindus move northward to a home of the infancy of their faith.

I have seen many pilgrimages—pilgrims from the farthest confines of the Roman Church drawn to Lourdes for healing; pilgrims on their way to Mecca; Russians from Siberian wastes come down to the Jordan for the dipping of the shrouds that will enwrap them when they die; Hindus from far Ceylon bathing in the sacred river at Benares—but this pilgrimage in Nepal was certainly in some way the most remarkable. Of those thousands of struggling men and women many were infirm and aged, some so worn by the hardships of the weary way that they would probably not live to see their homes again; a few who had money to spare for this advantage were huddled up in baskets on porters' backs.

The Gurkha, as far as Nepal goes, only dates from the eighteenth century. We are here concerned with the Newar, the original inheritant of the country. The Newar is Tibetan, as the Gurkha is supposed to be Rajput, in origin. His are the arts, the industries, the agriculture. All, then, that we see here in these pictures—architecture, woodcarving, metal work, stone is Newar in conception and workmanship. And although the pagoda in principle is Chinese, its detail is so entirely different from that which we are accustomed to see in works on China, its decoration is so vigorous, so unconventional, and so true to life, that Nepal may be said to have a distinct art of its own, and that art expressed by great artists.

The Newar is primarily an artist in wood, and his control over that medium is astonishing. The decorative forms of windows, doors or plinths are not confined to shrines or to houses of the well-to-do; it is a principle throughout the land, some of the poorest country cottages having most beautiful workmanship. The picture of a wayside cottage shows the same form of horseshoe-headed window, with its lattice, that we later find elaborated in the wonderful buildings of the town. For although geometrical design forms the basis of this work, it is not "left at that," as in the lattice screens of India and Burma, but, where the money was sufficient, is overlaid by a complicated tracery of foliage, flowers or animal subjects. These are not only in their main lines true to Nature, and therefore quite recognizable (notice the mango over the doorway), but are arranged in a well-defined scheme of composition in the most artistic way. The ability to portray well-known animals is common even to primitive people; the reindeer of the Cave-men are real reindeer, the antelopes of the Bushmen are unmistakably Oryx or Sable, as the case may be. But these people, each in their day, were the *children* of the world, and their drawings, like all drawings done by children, insisted on detail as the child's eye sees it.

The Newar artist had advanced a long step farther; he was no nursery artist—he had "arrived." He knew exactly how to generalize, how to insist on the big features that gave his plant or his animal its recognizable character and individuality, and how to drop all those details that did not tell. And this was equally true whether he worked in wood or in metal; less so, perhaps, in stone. For all that, when form demanded it, he could be as strictly conventional as a Greek. As examples of this, notice the conventional lotus on the well-head and on the capitals of the monumental columns.

Two types of temple are noticeable in these pictures—the Chaitya type and the Pagoda type. The first is the Buddhist form, the other is Nepalese Hindu. These latter are not found, I believe, in India, if we except one that stands out unmistakably among the temples of Benares—the pious gift of a Maharaja of Nepal. It will be noticed that each story of these pagoda temples is supported by long wooden struts. Recourse to such a device to support an overhanging plinth or other structure is elsewhere common enough; a familiar instance is that of the Ponte Vecchio. But the Newar has gone one better than the Tuscan, for he has carved each strut elaborately from end to end.

The shrines would take a paper to themselves. They are of wood, metal, and stone. In noticing their extraordinary wealth of decoration, it is necessary to realize that nothing is introduced without a meaning; that each detail, decorative as is its effect, has a distinct and definite significance in the religious sequence of a people's worship.

The doorway of the Durbar Hall in Bhatgaon is, of course, well known as one of the greatest achievements in metal in the world. It is of copper overlaid with gold. It is, indeed, a thing of fascination; the folds of its serpent seem to writhe, the lizard on its lintel might be darting in the heat.

But of all the remarkable and beautiful features of the streets of these Nepalese cities, nothing holds the attention so strongly as the monumental statues. I do not know whether these are absolutely peculiar to Nepal, or whether they are also met with in Tibet; the writer, at least, had never seen anything like them. They are sculptured portraits of various rulers who built the temple in front of which they stand. First there is a simple base, then a square stone pillar, perhaps 30 to 50 feet high, then a beautiful capital of lotus pattern. On this is placed sometimes a throne of copper gilt, based on animals—elephants or others. On the throne the Newar king is seated, with the cobra or a gilt umbrella as a canopy above him. In some examples his family are about him; in others he sits upon no throne, but kneels in an attitude of adoration before the temple of his gods. No description could adequately convey an idea of the extreme and beautiful dignity of these monuments. What they owe to their surroundings it is impossible to say; they belong to Nepal and not to Trafalgar Square. There are, at any rate on the Maidan of Katmandu, some very fair equestrian figures of Maharajas that are of western making; and to come upon these after the others was to change the sublime for the commonplace. Seen where they were, these columns of the rulers seemed structurally, decoratively, spiritually, and in their beautiful repose, a final word in art.

The Combustion of Coal in Boiler Furnaces

In a preliminary report on a series of experiments conducted by J. K. Clement, J. C. W. Frazer, and C. E. Augustine on the factors governing the combustion of coal in boiler furnaces at the Bureau of Mines, the following practical points are noted. These suggestions, together with a detailed account of the first of a series of experiments on the above subject, will be found in Technical Paper No. 63, issued by the Bureau.

The efficient use of coal is dependent on proper furnace design as well as on proper firing and control of the furnace. Many furnaces are built without regard to the special characteristics of the fuel to be used, with the result that for years fuel has been burned in an inefficient and wasteful manner, and so as to aggravate the smoke nuisance.

In the design of boiler furnaces the requirements of efficient combustion have been made secondary to many less important factors, largely because of a lack of definite information about the processes of combustion.

The combustion of coal may be considered as taking place in two stages: (1) Distillation of volatile matter and partial combustion on the grate, and (2) combustion in the combustion chamber of the gases rising from the grate. In order that the second stage of the process may be complete, it is essential that the combustible products given off from the fuel bed remain long enough in the combustion chamber to be entirely burned before they become chilled by contact with the relatively cold boiler surface. If the combustion space is too small the gases will pass out of it only partly burned, and a loss in heat and a lowering of efficiency will result.

Combustion is influenced by many factors, the most important of which are the following: The volume and shape of the combustion chamber; the kind of fuel used, especially the amount and character of the volatile matter and rate of firing; the rate of heating the fuel; the air supply; the rate at which air is mixed with the combustion gases in the furnace; and the temperature of the combustion chamber.

The composition, as well as the amount, of volatile matter given up by a given coal varies greatly with the temperature to which the coal is heated and the rate of heating. The influence of temperature on the amount and composition of the volatile matter distilled from various coals has been studied by Porter and Ovitz of the Bureau of Mines.[1] They found, for example, the following values for the volume of combustible gas given off in ten minutes from 10 grammes of air-dried Pocahontas coal:

RELATION OF TEMPERATURE OF FURNACE TO VOLUME OF COMBUSTIBLE GAS.

Temperature of furnace, deg. Cent.	600	700	800	900
Volume of combustible gas, cubic centimeters	50	670	1.570	2.300

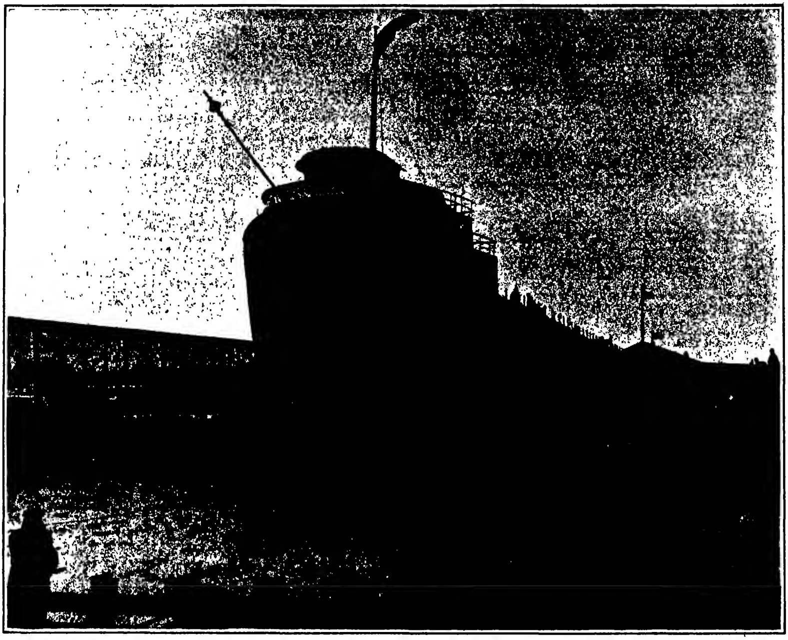
The amount of tar produced increases with increase of temperature in about the same proportion as does the volume of combustible gases.

The heavier constituents of the volatile matter, especially the tar, do not burn readily and require more time for combustion. The higher the temperature at which distillation takes place, therefore, the greater is the amount of volatile matter drawn off and the more difficult is the combustion of its constituents. A rapid rate of heating of the fuel produces a rapid evolution of slow-burning volatile matter. A slow rate of heating results in a gradual and uniform liberation of volatile gases, which are more readily combustible. One advantage in the use of the automatic stoker over hand firing is that in the automatic stoker the coal is heated gradually through the temperatures at which distillation takes place, whereas in hand firing the green fuel is thrown on the incandescent fuel bed and thus heated from room temperature to the furnace temperature.

In the tests described in this report the supply of coal was regulated automatically and the rate of heating was constant for each rate of firing. In a future investigation it is planned to vary the rate of heating the coal and to study the relation between the rate of heating and the volume of combustion space required.

With the type of stoker used in the tests the coal is fed continually to the grate, and with proper regulation of the speed of the stoker engine the thickness of fuel bed may be kept fairly constant. In the tests with Pocahontas coal the thickness of bed carried was about six inches. No attempt has been made to study the relation between different thicknesses of fuel bed and the space required for combustion. There is ample evidence at hand to show that excessive thickness of bed favors the formation of CO by the reaction: $CO_2 + C = 2CO$, the reaction that takes place in the gas producer. Increasing the thickness of the fuel bed, therefore, not only reduces the combustion space above the bed, but produces greater quantities of CO, and thus increases the volume of combustion-chamber space required.

[1] Porter, H. C., and Ovitz, F. K., The volatile matter of coal: Bull. 1, Bureau of Mines, 1910, 56 pp., 1 pl., 9 figs.



The largest built freight carrier on the Great Lakes, just after launching.

Freight Carrying on the Great Lakes

Where Immense Quantities of Grain, Ore and Coal Are Moved in Bulk

By Day Allan Willey

WHAT is claimed to be the largest bulk freight steam ship in the world has been constructed at Port Arthur, Canada, to carry grain between ports on the Great Lakes, and has a capacity of 585,000 bushels, or approximately 20 trains of 30 cars each. It is 625 feet long, 59 feet beam and 32 feet deep, with a water bottom, and side tank 5½ feet, extending from the keel, up to the main deck, and from the collision bulkhead back to the engine bulkhead, and divided by a center keelson, side bulkhead and solid floors into fifteen watertight compartments, which may be flooded or pumped out individually, as conditions may require.

The construction was on the Isherwood system, consisting of longitudinal frames with transverse sections of plate and angle, spaced every 12 feet. The cargo hold, 430 feet in length, is divided into six compartments by five solid steel bulkheads, entrance to which is gained by 38 steel hatches, opening from the spar deck, and spaced 12 feet centers. These hatches are 9 feet wide by 41½ feet long, and are covered with sectional steel plate folding covers, operated by steel cables from two deck winches, and clamped down with a patent hatch fastener especially designed for this type of cover.

The power plant includes one vertical, triple expansion engine, with cylinders 24, 39, 65 by 42 inches stroke, having an indicated horse-power of 2,000 at 85 revolutions per minute. Steam is furnished by two Scotch boilers 16 feet diameter by 11½ feet long with induced draught, working under the pressure of 170 pounds per square inch.

The steering engine is of the direct acting type, with 9- by 9-inch cylinders, operated with telemotor gear.

The electro lighting plant consists of two 15 kilowatt generating sets, installed in the engine room, with separate circuits fitted for the different parts of the ship, including electric mast head, stern and side lights, so arranged that should any of these lights go out, the fact will be instantly noted in pilot house by pilot lights installed therein, which are lighted automatically. One of the two 10- by 30-inch whistles is also electrically controlled.

A feature very seldom found in the freight carriers is an ice machine large enough for refrigerator coils and ice tank of two tons capacity. The spar deck forward is fitted up for passengers, and is finished in full panel of mahogany, containing four staterooms and bath, opening off a large reception room, which communicates by stairs to an observation room on the forecastle deck above.

The captain's quarters are in the "Texas," and are finished in quartered oak, including office, a bedroom and bath, with a stairway leading into a pilot house directly overhead. The forward crew's quarters are located on the main deck, and are finished in oak with white pine ceilings, each room containing berths for two people, with exception of the mate, who has a separate room. These quarters include bathroom, shower bath and large reading room for the sailors. The after deck house contains a private dining room for passengers, finished in quartered oak with white pine ceiling, and a dining room for officers and a mess room for the crew.

The chief engineer's quarters consist of office, bedroom and bath, and forward of him are the assistant engineer's, oilers', and firemen's rooms in separated quarters on starboard side. On the port side are located quarters for deck hands, stewards, the galley, and ice box.

British Shipping Tonnage

STATISTICAL tables issued by Lloyd's Register give the merchant vessels of the United Kingdom on December 31st, 1914, approximately as follows:

	Vessels.	Gross tons.
Steam	12,854	19,145,146
Sail	8,203	864,384
	21,057	20,009,530

This is the first time, says the *Shipping Gazette*, that the figure of 20,000,000 tons has ever been reached, and it was attained after five months' effort on the part of the second greatest maritime power to wipe, if possible, our merchant shipping off the seas. To make the impressiveness of the figures still more clear, let us add that the tonnage referred to is that registered in the United Kingdom alone, for it does not include that registered in other parts of the Empire; and that the corresponding figure on December 31st, 1913, was 19,604,900 tons.

Consequently, during a year, which includes five months of ocean warfare, the register of the United Kingdom has increased by 404,630 tons of shipping. But it is really better than that. There were added 462,107 tons of steam, and removed 57,477 tons of sail. Thus the net gain of 404,630 tons is a much larger addition than it appears, because steam tonnage is more effective than sail, in the proportion of three to one.—*The London Daily Telegraph.*

In the hold during construction, showing arch and longitudinal system of framing used in many modern bulk freight carriers.

Utilizing Wastes in Canning Pineapples

A FULLY ripened pineapple, of the more desirable kinds, is so delicate that it will not stand transportation for long distances, so there are few regions where this delicious fruit is in its best form; but the perfection of modern canning processes now makes it possible for people anywhere in the world to get the pineapple in a really desirable and satisfactory form.

In the business of canning pineapples Hawaii has taken a leading position, a result of abundant supplies of fruit of a superior flavor, and the most modern and sanitary methods of packing, and the growth of the industry is indicated by an increase of from 2,000 cases in 1901 to over two million cases in 1914. This phenomenal growth of the packing plants has left little time for the study of details, and heretofore there has been considerable waste in the processes; but that this is being corrected is shown by the following notes from a pamphlet on the industry recently published by the Department of Commerce.

Within the last year or two a demand has been created for the cores, which were formerly thrown away. These cores are not unusually stringy or tough in the ripe fruit of the Hawaiian pineapple, and make a much-liked product of the confectionery trade when manufactured into chocolate-coated or glacé pineapple. At one of the factories it was stated that the demand for these cores was greater than the supply and that some attempt had been made to cut the whole pineapple into square strips about the size of the core to correspond with the Singapore chunks. This has not proved altogether successful, however, because the flesh is too tender to hold together after opening the cans and during the process of further manufacture by the confectioners. The cores are usually packed whole, but a few are cut into shorter lengths. They constitute about 5 per cent of the entire pack. One of the larger factories has been unable to dispose of all the cores produced, and this suggests that a proper campaign among the confectioners using pineapple might result in the substitution of Hawaiian cores for Singapore chunks, in view of the superior flavor and texture.

The greatest waste existing up to the present time in packing was from the loss of the juice. The pineapples as brought in from the fields are fully ripe, and the fruit is permeated with a luscious juice, which is pressed out and wasted at every process of cutting and handling by the various machines. The disposition of this juice had become a source of considerable expense during the busy season, and in some of the larger canneries more than 10,000 gallons were daily pumped into the sea. To avoid this expense, several of the factories have commenced bottling the juice. One of the methods followed in the bottling is as follows: After being caught in vessels or troughs placed under the different machines the juice is placed in a press and strainer to separate it from any particles of fruit that are collected at the same time. It is then pumped through aluminium pipes (which are not affected by the acid of the fruit) to a filter through which it percolates. It is then brought to the boiling point in a silver-lined vat, after which it is bottled, sealed, and processed. Great care is taken not to fill the bottles too full. The juice is not sweetened, as it contains about 7 per cent sugar and can be used as a beverage without sugar or water. It is improved by the addition of crushed ice. As this is only a comparatively new product, the quantity so far bottled has not been large. If the market can be developed as rapidly for this product as it has been for the canned pineapple itself, a valuable addition will have been made to the earnings of the various canneries. A promising market for this juice should be found in tropical countries where beverages of various sorts are constantly used, especially in the countries where religious principles have made the inhabitants total abstainers from fermented or strong liquors.

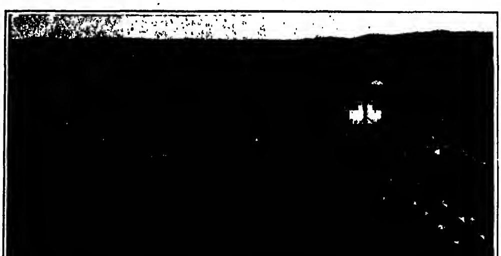
Various experiments along different lines have been made during the last few years in an endeavor to find a use for this juice by-product in the manufacture of alcohol, vinegar, or other experimental products, but the great demands already made upon the various companies in keeping pace with the growth of their factories or in the study of machinery fitted to simplify the preparation of fruit for canning have made it impossible to devote much time to such experiments.

What promises to be a satisfactory utilization of the juice, however, has been evolved by a San Francisco firm of chemists who, in March, 1913, began some laboratory experimentation with the idea of developing processes by which pineapple juice might be made to yield a revenue. A systematic research was conducted, with the result that definite processes and products apparently of a satisfactory quality were developed. One of these was the extraction of sugar from the pineapple juice, which could be used as sugar syrup in canning, thus relieving the pineapple companies of the necessity of purchasing sugar for canning purposes. The first step was to interest capital for the commercial operation of these processes. Several of the largest producers of pineapple juice were approached and an option asked for a period of one year on all the waste juice produced. A small commercial experiment was carried out during June, July, and August of 1913, and sufficient sugar syrup was produced from the juice to can sixty cases of pineapple. This syrup was submitted to the various canners and thoroughly approved as satisfactory. Test cuts were made of the pineapple canned with this syrup and seemed thoroughly satisfactory during the following fall and winter. Contracts were then made with several of the larger factories to deliver all of their waste juice to the new concern for a period of ten years from June 1st, 1915. The agreement carried with it the repurchase from the new concern of all the sugar syrup produced from the waste juice at the market price for refined sugar on the molt basis. The net profits resulting from the recovery of the waste is to be equally divided between the pineapple companies and the new sugar-producing company. The contracts allow the new company the period of one year in which to erect an experimental plant sufficient in size to produce syrup to pack 10,000 cases of pineapple, and if at the end of this experiment the syrup proves thoroughly satisfactory and the cost of recovering is such that the project will prove a profitable commercial undertaking, the ten-year contract will become effective and the new company will be required to handle all of the waste juice produced by the pineapple companies with whom they have made this agreement.

Buildings and equipment costing in the neighborhood of $80,000 are now being constructed and will be capable of handling 50 tons of waste juice per day. The buildings under construction are three in number—one to be 120 by 60 feet, one story high; one to be 60 by 40 feet, three stories high; and a building for a 100 horse-power plant. This factory will handle 50 tons of waste per day of ten hours, and is estimated to produce 5 tons of sugar equal to 10 tons of canned syrup. This new plant is located near two of the largest pineapple-canning establishments in Honolulu and the waste will be carried from them to the recovery plant by a pipe line and the syrup returned to the canneries by the same method. If the results obtained from this $80,000 experiment are thoroughly satisfactory to the producers and the new company, the contracts call for an enlargement of the plant to handle 250 tons of waste per day. As a matter of fact, since the ripening of the pineapple cannot be controlled, it is planned to enlarge the plant so that it will have a capacity of approximately 500 tons of waste per day. This equipment will cost in the neighborhood of $250,000.

No attempt will be made at first to produce in commercial quantities other products that are recoverable from the juice, but the experiments indicate that the sugar for syrup will not be the only product that will eventually be recovered in the new plant.

The experiments of making fiber from the leaves of pineapple plants that are no longer fit for bearing fruit seem to promise a further utilization of the waste. Experiments carried on in Hawaii at the sisal mills produced a satisfactory fiber.



View of the deck framing of the "Morden" during construction. The tracks for the traveling crane used in building are seen on each side.

Atoms and Ions—VI*

A Comprehensive Discussion Especially as Related to Gases

By Sir J. J. Thomson, O.M., F.R.S.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2056, Page 347, May 29, 1915

In the final lecture of his course on the above subject, Sir J. J. Thomson said that on the last occasion he had shown an experiment in which a piece of paraffin was converted into a conductor by the action of polonium rays. In this case we had an insulator rendered conductive by exposure to an agent which was known to be capable of ionizing a gas, and which, it was fair to presume, should accordingly also be able to ionize the molecules of a solid. The conductivity of solids formed a very interesting subject, but there was not time for him to consider more than one or two special cases, which were particularly closely allied to the effects he had discussed in this course of lectures.

One well known case of the conversion of a solid from an insulator into a conductor was afforded by the Nernst lamp. The filament of this lamp was a mixture of different oxides, and when traversed by a current glowed with great brilliancy, constituting a very convenient source of light for many purposes. The peculiarity of the mixture of oxides used was that its conductivity increased enormously as the temperature rose. Being an insulator when cold, before a current could go through it its temperature had to be raised by artificial means. Once the current got through, however, the heat developed by the very passage of this current caused the filament to get hotter and hotter, till it finally glowed with the greatest brilliancy. The oxides used were specially selected to give this brilliant light, but very possibly the phenomena involved were of the same order as with oxides of calcium and barium. Dr. Horton, working at the Cavendish Laboratory, had measured the resistance at different temperatures of these two oxides, and found the increase of conductivity with rise of temperature was quite parallel to the simultaneous increase in the number of negative particles emitted from a fragment of lime or of barium oxide when heated on a strip of platinum. Such a fragment of barium oxide was conveniently obtained by dropping a little sealing-wax on to the platinum and then heating the latter to a high temperature. Barium oxide was very heavy, and for this reason was added to sealing-wax, which was sold by weight, and hence the cheapest wax was the best for the particular purpose in view. When the platinum carrying such a speck of lime or of barium oxide was heated, negative particles were given off which might serve to carry a current through the lime, and a similar effect might account for the conductivity of the oxides used in the Nernst filament.

The rate at which these negative particles were emitted from lime and barium oxide had been measured by Richardson, so that the number coming out at different temperatures was known. Dr. Horton had compared Richardson's numbers with the conductivity as measured by himself at corresponding temperatures, and found a close agreement between the two. There was thus considerable evidence that, at any rate, part of the conductivity of the oxides was due to the liberation of these negative particles. An interesting point was that the emission of these particles was very feeble if metallic calcium or barium was used in place of the oxides, from which the number emitted was many thousand times as great as from the metals. Apparently the emission depended on, or was increased by, the mutual presence of two substances having a considerable chemical affinity one for the other.

In this connection he might, he continued, refer to a question which had been submitted to him by one of the audience, as to why the sulphides of certain metals were much better radiators than were the pure metals. It was known from Kirchoff's law that, unless other besides purely thermal effects intervened, the sum of the light emitted and the light reflected from any body depended only on the temperature, and not at all on the nature of the body. This sum constituted the so-called "black-body" radiation. Hence, if a body was a very good reflector, it would only have to emit a little radiation on its own account, while if dull, as when tarnished by sulphide, it would not reflect so much, and must therefore radiate more. He was informed, however, that the difference in the radiating power of the two was much greater than could thus be accounted for. If so, the phenomenon was a very interesting case of what was called chemical luminescence, in which we got radiation from a body at quite low temperatures. For example, phosphorus glowed even at ordinary temperatures. It had also lately been established that a solution of hydrogen peroxide in contact with certain substances would give quite an appreciable illumination. These were cases in which the light did not obey Kirchoff's law, but was drawing upon other sources of energy, in addition to the purely thermal. In the case of lime oxide, there was the possibility of chemical action going on. Barium had, it was known, two oxides, and it was quite possible that calcium possessed the same property, and this might account for the differences observed between the oxide and the pure metal. There might, in fact, be some chemical action going on between the calcium and the oxygen, and similarly, with the sulphides, there might possibly be decomposition of one sulphide and formation of another, or some other form of chemical action might be taking place. In this way there might be local temperatures in excess of the average, some few molecules having very high velocities, though the mean was very much less. In considering radiation, it was important to remember that a few molecules at a very high temperature were much more effective than a lot at a low temperature. Hence, if chemical action caused a few molecules to have a temperature in excess of the normal, the net radiation would be in excess of its ordinary value.

The foregoing was, he said, merely a suggestion, but the observation in question appeared to bring this question of chemical luminescence into a more definite form than hitherto, the treatment of the subject in the past having been more allied to cookery than to chemistry. One experimenter discovered one instance of it, and another worker another example, no very definite connection between the two being established. In all known cases, however, oxygen was invariably present. It was believed by some that even flint sparks were examples of chemical luminescence, due to the oxidation of the freshly exposed surface of the flint, and it was asserted that the cracking of flints was associated with a strong smell of ozone. Local increases of temperature would mean not merely a very great increase in the radiation, but also a change in its character, since the hotter the radiating body, the bluer the light it emitted, the center of gravity of the spectrum being shifted toward the violet end. Hence, in dealing with cathode rays, the light was bluer the faster the particles.

The communication by electrified particles of their charges to metal or other bodies with which they came in contact was not, the speaker continued, so simple a matter as might be expected. It was easy to say that on coming into contact the charge was given up, but a good deal had to be effected during the exchange. A positive particle was one which had lost a negative charge, and when such a particle came up to a metal plate it meant that, in order to become neutral, it had to get out of the plate a negative charge. Similarly, a particle carrying a negative charge had to stick this charge on to some atom or molecule which already had its full complement.

It was thus *à priori* conceivable that this process of getting rid of a charge and fixing it on to a metal plate was not so easily effected as was often imagined.

Many years ago, the speaker, when working with a highly exhausted bulb, had earthed a pool of mercury lying in the bulb with a view to removing electricity from the tube. The arrangement did not work as well as had been expected, electricity being still found in the tube after the lapse of several hours. The mercury, therefore, had not been able to discharge the gas. Recently Franck and Hertz had shown that different substances possessed different powers of absorbing electricity from these particles. Some atoms and molecules seemed quite incapable of retaining one of these negative particles if the velocity were less than a certain critical limit.

The principle of their apparatus is represented in Fig. 1. The cathode was a heated wire placed inside a tube, as indicated at *A*, to prevent particles getting out laterally. From the hot wire negative particles were driven off by the potential of the wire, and followed a curved path through the gas to the collector-plate *B*. Above this plate was a wire gauze, which could be connected up to the negative pole of a battery, and would thus oppose the passage of the particles to the collector. It was found that the particles shot off from the cathode, in spite of the collisions they had to encounter from the gas in the tube, made their way to the collector-plate even when the gauze above the latter was at a negative potential of as much as 6 volts (in the case of certain gases), the total potential between the cathode and the collector-plate being, say, 12 volts. In all the thousands of collisions they had experienced, many of the particles had not succeeded in sticking on to the molecules encountered. The effect was most marked with argon, neon, and helium, with which there was practically no communication of energy between the particles and the molecules. On this head it should be borne in mind that inter-communication of energy between colliding elastic particles was easy when both colliding bodies were of the same size. When, however, one body was more than 1,000 times that of the lighter body, the latter bounded off with practically unchanged energy, each particle retaining what it had before the encounter. Hence, if a negative particle passed through the midst of one of these inert gases, the collisions would merely check its rate of progress toward the collector-plate; but as the particle lost none of its energy in the collisions, it finally arrived at the collector-plate, belated, but with practically the whole of the energy due to the difference of potential between this plate and the cathode.

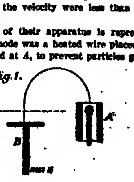
When the inert gases were, however, replaced by oxygen, then at every collision the particle lost some of its energy, and when it ultimately arrived at the collector-plate, did so with only a small fraction of the energy due to the fall of potential, having retained practically none of the energy given to it during its passage. Hence, the only way to obtain negative particles moving with much energy through oxygen was to reduce the number of collisions by reducing the number of oxygen molecules present, otherwise the energy would be knocked out of the particles as fast as it was acquired. With argon, helium, and neon, on the other hand, the number of molecules present did not matter to the same extent. Though the particle might take a long time to get through a dense crowd of helium molecules, when it finally did arrive, it carried with it all the energy it had acquired in falling through the potential difference between the electrodes. It was thus possible to get luminous effects with helium, neon, and argon at pressures impossible with oxygen. Possibly if oxygen could be completely eliminated, similar results might be obtained with other gases as well as with the three named.

To illustrate how easily luminous effects were obtained with neon, the lecturer took a tube filled with neon, and having a little mercury in it. The tube had a number of constrictions, and on inverting the tube, the friction of the mercury falling through the constrictions electrified the walls, with the result that the neon glowed brightly with its characteristic light.

From this point of view, it appeared, Sir Joseph proceeded, that certain special properties of neon were closely associated with the behavior of its atoms, which, when struck by a negative particle, did not pick up any energy from the latter.

If other bodies resembled neon, it would be very difficult to get electricity into or out of them. If, for instance, metals resembled neon to any extent in this regard, the formation of double layers would be obvious. If there were a difficulty in getting electricity out of an electrified gas, the result would be that the surface of the metal would get charged up with a double layer. If the gas were positively charged, the molecules would stick close up to the surface of the metal, their condition being masked by the negative electricity immediately induced on the surface of the metal. The two electricities would, however, not combine, and the positively charged molecules would possess the potentiality of getting away again. This formation of double layers was a frequent source of difficulty in experimental work with gases at low pressures, the gas being liable to get loose again, giving rise to local creeping of the electricity.

Fig. 1.



*Reproduced from *Engineering*

Again, the attempt was often made to produce a potential in a gas by shooting it through electrified wire gauze, on the assumption that all particles that passed the gauze would acquire the potential of the latter. This, however, would not be the case if a double layer formed on the wires. The danger of a finite difference of potential between the gas and the gauze was, no doubt, less the higher the potential of the latter; but the speaker believed that in some experiments errors of as much as 12 to 15 volts had arisen in this way. The danger was a real one, and, in the case of small potentials, might be serious.

Another problem was, what happened when a gas was ionized by the removal of a negative particle. Was the molecule left behind intact, or did we get sometimes the molecule split up into atoms as the result of the shock, so that we had as a result the charge carried by atoms, and not by molecules? For such a smashing of the molecules ample energy was available, and the question was, did it happen? Experiment showed that at low pressures it did. An investigation into the nature of the positive rays showed that the carriers might be all kinds of things. Some were atoms, others molecules left intact, the shock having been insufficient to split them up, and, in addition, various queer compounds were found among the carriers. It might be asked whether this variety was due to the method of production. In the discharge-tube there were, besides the negative particles, large positive systems, and it might be thought that the latter alone were capable of smashing up molecules into their component atoms, while the negative particles when they collided merely detached a charge.

To test this the speaker had adopted an arrangement by which the number of negative particles could be enormously increased in comparison with the positive carriers. If the negative particles were incapable of splitting up the molecules, the final analysis—by the positive-ray method—should show a much larger number of molecular carriers than before. The method adopted to increase the number of negative particles was to use as cathode a wire heated by an independent current. By increasing the temperature of the wire the number of negative particles emitted could be enormously increased. A photograph of the positive rays was then taken, first with the cathode cold, and next with it at a high temperature, and the two compared. This comparison showed little difference in the proportion of atomic and molecular carriers, but, if anything, the heating of the cathode slightly increased the proportion of charged atoms. This experiment afforded strong evidence that the negative particles could themselves split up the molecules into atoms, and that to effect this it was not necessary to have the big positive carriers. Not only this, but the particles were also able to split up these molecules in all kinds of additional ways. Thus, when water was decomposed by dissolving a radium salt in it, the gases liberated contained notably less than the proper proportion of oxygen. In fact, in some experiments Debierne had got nothing but hydrogen, and a subsequent examination of the water showed this to contain peroxide in solution, so that the oxygen liberated by the negative particles emitted by the radium had gone to oxidize the water, acting thus in quite a different fashion from that which occurred with other methods of decomposing water. The speaker thought that the queer combinations found among the positive rays must be brought about in a similar way, the results often being such as could not be effected by ordinary chemical reactions. Sometimes more than one negative particle was knocked out of an atom. The most exaggerated case known to the speaker was afforded by mercury, where in certain cases as many as seven negative charges were removed from the atom.

Fig. 2.

Thus, Fig. 2 represented a positive-ray photograph of mercury. All the lines shown were due to mercury atoms. In the case of the lowest line the atom had lost one charge before reaching the plate, while to get the uppermost curve seven charges must have been knocked out. Moreover, a comparison of the relative strength of the different curves led to the conclusion that the whole of the seven were knocked out in a single collision, and not successively.

Safety in Good Lighting

While a very conspicuous advance in lighting methods has been made by progressive manufacturers, notably in the iron and steel industry, there are still a large number of manufacturers who seem to regard the lighting as an expense to be reduced to the lowest possible minimum.

The economic value of good illumination, aside from accident prevention, is evident when we consider the greater facility with which an employee can work under good illumination, and the greater accuracy with which gages can be read and tools set.

One large manufacturer, on investigating his lighting conditions, found certain departments in which, during the winter months, the operatives were practically idle for about an hour a day solely on account of darkness.

Good artificial illumination can be furnished in such a factory for eight hours a day at a cost equivalent to about five minutes of the time of the workmen benefited. This illustrates the extravagance of poor lighting.

The question of safety as influenced by illumination presents two phases: First, the prevention of accidents; and second, the preservation of eyesight. While these two phases are often closely related, there are many conditions in which they are entirely independent of each other. The phase of accident prevention is illustrated in the case of the foundry or other shop where cranes or other powerful machinery are in operation.

The liability of crane and elevator accidents is very much reduced with proper lighting.

In the foundries and yards of a plant, it is practically impossible, even with safety committee inspection, to eliminate irregularities under foot. If not illuminated these may readily cause falls, with resulting injuries; and in foundries where molten metal is carried and hot metal abounds, they may often cause serious burns.

Even though guarded to the fullest extent, powerful machinery—in which materials are machined and fashioned into articles of commerce, and in which the arms and limbs are as readily crushed—presents a menace unless the operatives are given an opportunity to see and thus avoid the danger points.

There is practically no manufacturing operation which can be carried on without accurate visual inspection. Some of these operations produce considerable strain even under good illumination, and to require their performance under poor illumination is certain to result in more or less rapid impairment of vision.

It has been found by observation that the most common defect in factory lighting comes from excessive glare and absence of diffusion. Glare is usually caused by bright lights in the field of vision. This may emanate from the light source directly or may be deflected to the eye by a glossy surface; it can also be caused wherever excessive contrast of intensity appears in adjacent fields of vision. The dazzling effect is not only unpleasant, but interferes with seeing. Under continued exposure, eye strain and even permanent injury to the eye may result.

[illegible] stairways have been so arranged that, on descending, one could hardly see where to step on account of the glare. Such conditions are conducive to bad falls, whereas if the eyes were properly shielded from the glare, a lower intensity would have been ample.

The unshielded light hung over a machine is a common source of eye fatigue. The glare may not be very evident at first glance, but when the workman's eyes have been subjected to such light for a long time, discomfort and inability to see are the result. The proper correction should be to shield the light by means of a proper reflector, and as such a reflector would tend to direct more of the light upon the work, the working intensity would be increased; so in many cases it is possible to reduce the size of the lamp, or better yet, to relocate the lamp so as to enlarge the area illuminated.

When a light cannot be removed entirely from the field of vision, its brilliancy should be reduced by means of a diffusing globe or reflector, so as to increase the apparent size of the light source and reduce the contrast between it and the background. This has the additional advantage of reducing the sharpness of shadows in the illumination, a result which is of considerable importance in rendering the various parts of the machine or object readily discernible.

Glare received from specular reflection of glazed paper, desk tops, polished metal, etc., often induces eye trouble, headache, and other indispositions, though the sufferers may not be aware of the cause. The remedy is to change the relative positions, so that the reflected light is kept out of the eyes as much as possible, and to enlarge the dimensions of the light source.

Another defect commonly found in industrial lighting is improper distribution. This may be due to too wide a spacing of light units. Under this condition some parts of the room are insufficiently lighted while other parts may have more light than is necessary.

Improper direction of light may illuminate the wrong side of the machine, leaving the important parts in shadow. If the bright parts are near the shaded ones whatever illumination may fall upon the shaded portion is rendered less effective by contrast.

Unsteady or flickering illumination is always objectionable; both on account of discomfort and inability to see. Such variation should always be avoided, whether caused by the units themselves or by the light passing through moving wheels, etc.

Since the purpose of the lighting is to enable the operative to see, good illumination cannot be prescribed without a knowledge of the use it is to receive. In order to plan the lighting of a factory properly, one should be familiar with the processes employed, the arrangement of the machinery and the work tables, as well as the quality of the product manufactured. Practice has established certain methods of lighting which, if properly applied, are satisfactory for the different processes of manufacture. Thus we know approximately how much illumination is necessary for the ordinary grade of work performed on a lathe, as well as the desirable direction. As far as possible, therefore, the experience gained in well-lighted factories should be utilized in planning any lighting installation.

The practice in factory lighting has developed along a few fairly definite lines, which may be designated as localized lighting, general lighting, combined general and localized lighting and localized general or group lighting.

Localized lighting originated with the low-power portable or semi-portable lighting units. These were under the control of the individual workman, to be placed or shifted wherever he desired. Such lamps were commonly used without reflectors and produced small patches of uneven illumination, as well as more or less glare. In many cases lighting with these lamps is now being supplanted by other methods.

There are, however, certain operations which require light inside of a small cylinder or other inclosed space; or where very high intensities are required over small areas, and for these no other method is as practicable as localized lighting. For such conditions, the lamp should be equipped with a reflector to shield the workmen's eyes and reflect the light in useful directions.

General lighting is provided in three principal ways, which are known as direct, indirect and semi-indirect lighting. Direct lighting, depending upon the equipment, may have excessive brilliancy or any degree of diffusion. It is used to a much larger extent in factory lighting because factory ceilings are seldom good reflectors. Direct lighting units are less affected by dust accumulations. The indirect and semi-indirect give excellent diffusion, and are often applied with good effect in offices and drafting rooms when light ceilings are available.

"Combined general" and "localized lighting" is often desirable. With this, a low general illumination is supplied by large units and more intense localized illumination at particular points by low-power units. The localized lighting may be supplied continuously or temporarily as needed. For example, in lighting automatic machinery, a moderate illumination may be sufficient at all times except when a machine is being inspected, set up or adjusted, when a localized light may be needed.

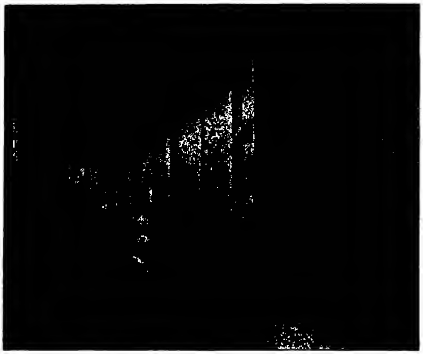
"Localized general" or "group lighting" is a recent practice which has sprung up since a range of intermediate sizes of lighting units has become available. This practice differs from general lighting in that, instead of striving for even intensity throughout the room, lamps are arranged to give higher intensities and correct direction of light at the machines or tables and a lower intensity at intermediate points. It differs from localized lighting in being planned so as to give some illumination, sufficient for the needs, in all parts of the room. It is, therefore, an intermediate practice between the extremes of localized and general lighting. Its application is extending very rapidly, since it meets effectively and economically factory requirements for a large portion of the ordinary manufacturing processes and shop buildings.

Each of these various methods of lighting has some field in which it is to be preferred to any of the others. The selection depends upon the character and construction of the building, the process of manufacture, the source of energy available and various local conditions.—G. H. Stickney, in the *General Electric Review*.

Scientific Aeronautic Research*

The New Aerodynamic Laboratory of the Massachusetts Institute of Technology

By J. C. Hunsaker



Suction end of wind tunnel.

AIR CRAFT have become in the last few years primarily war material, and as such, are designed to meet definite specifications of performance. Five years ago the supreme test of an aeroplane was whether it could fly or whether it could not fly. Now we inquire how fast and how slowly it can fly, what is its rate of climb, useful load, and radius of action? For example, for military uses, armies require a slow endurance machine for strategic scouting which can make raids into the interior of an enemy's country. For tactical scouting over the field of battle, where enemy aeroplanes must be evaded, an army requires a scout of great speed but limited radius of action. Such a machine must have speed and climbing ability superior to that of the enemy units. A third type called a "fighting aeroplane" is necessary to drive off enemy scout aeroplanes. Such a machine must combine the greatest practicable speed and climbing rate with the extra weight of an armored body and a machine gun with a gunner. The performance required for such a destroyer is fixed by the probable ability of enemy scouts to elude it. A fourth type of military aeroplane may soon be developed for the purpose of bomb-dropping. Here the designer would be required to produce a machine able to transport great weight over a long distance.

In all the cases mentioned above the entire military value of the aeroplane lies in its performance, and the burden is thrown on the designer to produce a machine to meet all requirements. Just as in naval architecture the problem is a compromise between the conflicting claims of speed, armor, armament and radius of action.

In view of the necessity for designing aeroplanes to possess given qualities, a designer must guarantee performance. A desired type can, of course, always be reached by building a series of machines but this procedure is extremely costly in time and money, and requires a pilot to risk himself in experimental flights on under-powered and unstable machines.

The problem of aeroplane design involves so many variables that it is often impossible to arrange experimental flights so that changes are made in but one variable at a time. The peculiar conduct of an experimental machine may often be blamed on any one of some half dozen features of its design, and as a result the tests lead only to endless discussion.

On the other hand, it is well established that the performance of an aeroplane can be predicted from experiments on a small model, geometrically and dynamically similar. Model tests are easy to conduct and afford the great advantage that radical alterations of the model may be made without loss of time or risk of life. Furthermore, in model testing, the various parts of an aeroplane may be tested separately to determine the effect of each part on the performance of the complete machine.

In naval architecture, a designer has a small model of his ship towed in an experimental model basin. From the resistance of the model, he can estimate the resistance of his ship and so guarantee its speed for a given power.

For purposes of aeroplane or air ship design, it is possible to tow models in air in a similar manner. However, in aeronautics the problem is extremely complex since in flight, motion is possible along the three axes in space, as well as rotation about any of them. In general, the effect of the air on a solid object moving through it requires the measurement of three forces and three couples corresponding to the three axes of space.

Towing experiments become mechanically difficult to arrange, and in view of the high speeds required in aeronautics a long building like a rope walk is necessary. Such tests have been made at the Kiel navy yard in Germany and at the University of Paris. At the latter institution a dynamometer car running along a track carries objects under test mounted on a weighing mechanism. The tests are conducted in the open air and are subject to error due to gusty winds.

If it be accepted that aerodynamic forces depend on the relative motion of air and object under test, it is immaterial whether the object be towed in still air at a given velocity, or held stationary in a uniform current of air of the same velocity. The use of an artificial wind is the "wind tunnel" method, which has come into general use abroad. The doctrine of relative motion is fundamental in mechanics, and discrepancies between results of tests made by the two methods may be ascribed to the probability of errors due to the influence of the car and wind gusts in the towing method, and to irregularity in the flow of air in the wind tunnel method.

The validity of wind tunnel tests depends upon the uniformity of flow of the air. The production of a current of air that shall be constant in velocity, both in time and space, is a difficult problem.

When it was decided to build a wind tunnel at the Massachusetts Institute of Technology for use by students in aeronautical engineering, a study was made of the most successful wind tunnels abroad. The conclusion was reached that the staff of the National Physical Laboratory, Teddington, England, had developed a wind tunnel of convenient form and of a high degree of uniformity of flow. This tunnel was the result of a methodical series of experiments with wind tunnels of various forms, in which the following conclusions were reached:

1. Models should be placed in the suction stream leading to a fan where turbulence is least.

2. A four-bladed aeroplane propeller of low pitch gives a more steady flow than the ordinary propeller fan used in ventilation work, and a much steadier flow than any blower of centrifugal type.

3. The wind tunnel should be completely housed to avoid the effect of outside wind gusts.

4. Air from the propeller should be discharged into a perforated box of great volume, to damp out turbulence, and to return the air at low velocity to the room.

5. The room through which air returns from the perforated box to the suction nozzle should be at least twenty times the sectional area of the tunnel.

The wind tunnel of the Massachusetts Institute of Technology was built in accordance with the English plans with the exception of several changes of an engineering nature introduced with a view to a more economical use of power. An increase of the maximum wind speed from 34 to 40 miles per hour was thus obtained.

Upon completion of the tunnel an investigation was made of the steadiness of flow. It appeared that the variation of velocity with time and from point to point of the cross section was not more than one per cent.

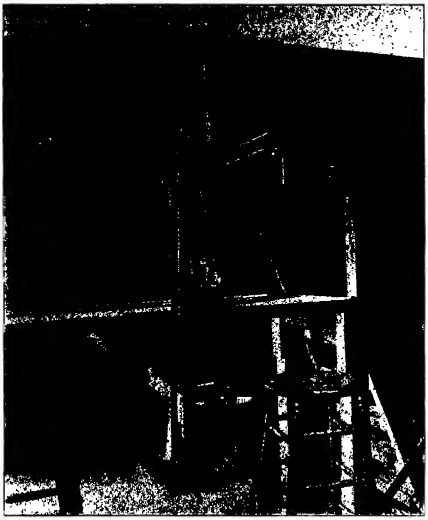
The wind tunnel proper is a square trunk 16 square feet in section and 53 feet in length. Air is drawn through an entrance nozzle and through the tunnel by a propeller driven by a 10 horse-power motor. Models under test are mounted in the middle of the tunnel on the arm of a delicate balance.

The air entering the mouth passes through a honeycomb made up of a nest of 3-inch metal conduit pipes. This honeycomb has an important effect in straightening out the flow and in preventing swirl.

Passing through the square trunk and past the model under test, the air is drawn past a star-shaped longitudinal baffle into an expanding cone. This cone ex-

Propeller for wind tunnel.

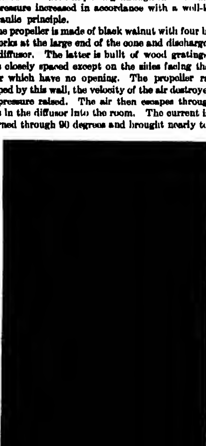
* From Science Conspectus.



Aërodynamic balance.

pands in 11 feet to a diameter of 7 feet. The velocity of the air is reduced in passing through the cone and has its pressure increased in accordance with a well-known hydraulic principle.

The propeller is made of black walnut with four blades. It works at the large end of the cone and discharges into the diffusor. The latter is built of wood gratings with holes closely spaced except on the sides facing the propeller which have no opening. The propeller race is stopped by this wall, the velocity of the air destroyed and the pressure raised. The air then escapes through the holes in the diffusor into the room. The current is thus returned through 90 degrees and brought nearly to rest.



Wing model in position for test.

The propeller was designed on the Drzwiecki system, which assumes that each blade section is an aeroplane wing moving through the air in a spiral path. In order to keep down turbulence, a very low pitch and a broad blade were used. To gain efficiency the blades were made thin and, therefore, weak. To prevent fluttering of the blades, the blade sections were so arranged that the centers of pressure of all sections lie on a radial line drawn on the face of the blade. This artifice seems to have prevented the howling at high speed commonly found with thin blades.

The propeller is driven by a "silent" chain from a 10 horse-power inter pole direct current motor. The propeller and motor are mounted on a bracket structure fixed to a concrete block and are hence independent of the alignment of the tunnel. Vibration of the motor or propeller cannot be transmitted to the tunnel as there is no connection.

In order to maintain a steady current of air, the fan must run at constant revolutions per minute, but in order to allow a fine adjustment to obtain and hold any speed, a direct current motor is necessary. To run a direct current motor at constant speed requires a steady voltage. Such is not available. Consequently the following procedure was adopted: A 15 horse-power induction motor is connected to the alternating current power mains of the Cambridge Electric Company. This induction motor is coupled directly to a 12 horse-power direct current generator. The generator supplies current to the motor which turns the propeller. For constant wind speed, the load is constant and hence the induction motor will turn over at constant speed since its slip is a function of load. Variation of voltage in the city mains has small effect on the speed of the induction motor, which runs at a speed proportional to the frequency of the supply current. The generator being turned at constant speed generates constant voltage, and the propeller then runs at constant speed. Due to slow changes in frequency it is necessary to provide variable resistance in the direct current motor field, by the use of which the wind speed can be corrected from time to time. Any wind can be made of velocity between 3 and 40 miles per hour.

The model of complete aeroplane, wing, tail, body or other part is mounted on an aerodynamic balance constructed from the plans of the National Physical Laboratory, England. This balance consists of a cast pillar mounted on an independent concrete block, and the balance proper. The latter is made up of three arms mutually at right angles representing the axes of co-ordinates in space about and along which couples and forces are to be measured. The model is mounted on the upper end of the vertical arm which projects through an oil seal in the bottom of the tunnel.

The entire upper part of the balance rests on a steel point, bearing in a steel cone supported by the cast iron pillar. The balance is normally free to rock about its pivot in any direction. When wind blows on a model, the components of the force exerted are measured by hanging weights on the two horizontal arms to hold the model in position.

The balance is also free to rotate about a vertical axis through its pivot. The moment producing this rotation is balanced by a calibrated torsion wire.

Special attachments permit the measurement of the force in the vertical axis and moments about the two horizontal axes.

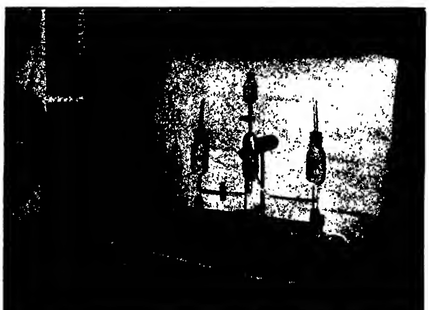
The three forces and three couples acting on any model placed in any attitude can be studied at leisure. The balance is precise to one per cent.

Velocity is measured by means of a Pitot tube which was calibrated on the whirling arm at Teddington. The Pitot tube pressures are read on a Chattock liquid micro-manometer. Velocity readings are precise to one half of one per cent.

Tests have been made to determine the lift and resistance of a model aeroplane wing which had previously been tested in England. The results are in excellent agreement and indicate that the English tunnel and balance have lost none of their precision in the rather extensive alterations that have been made here.

The wind tunnel has been in operation since July, 1914, and has been used for comparison of Pitot tubes, determination of the aerodynamic co-efficients for a number of wings, bodies, and miscellaneous objects, for thesis work on aeroplane stability and by students in connection with problems arising in the course of aeroplane design.

It is hoped that in following up design by wind tunnel testing, aeroplane design is being placed on a rational engineering basis.



Chattock micro-manometer (above), Krell manometer (below).

Development in Electromagnetism—II

A Review of Some Important Problems, and Laboratory Results

By Eugene Bloch, Professor at the Lycée Saint Louis

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2056, Page 339, May 29, 1915

III. ELECTROMAGNETISM AND RADIATION.

THE difficulties just described are not the only ones which the modern theory of electromagnetism encounters. Perhaps the gravest ones arise in adapting it to the experimental facts of radiation. We know that thermal radiation in equilibrium in a constant-temperature chamber, and called "black radiation," has a density independent of the particular body producing it. It is a function only of the wave length λ and the absolute temperature T. Our theoretical knowledge of this density, u_λ, is expressed by the well known laws of Kirchoff, Stefan-Boltzmann, and Wien.[21] Our experimental knowledge is expressed by the formula of Planck,

$$u_\lambda = c_1\lambda^{-5}\left\{e^{\frac{c_2}{\lambda T}} - 1\right\}^{-1}$$

This equation satisfies not only the three theoretical laws, but also corresponds to the observed distribution of energy in the spectrum of a black body. This formula reduces for large values of λT to the earlier one of Rayleigh,

$$u_\lambda = c_1/c_2 \cdot T/\lambda^4.$$

Now, the electromagnetic theory seems to lead almost inevitably to Rayleigh's formula for *all wave-lengths* in flagrant contradiction to experimental facts. The second formula, indeed, does not give a maximum in the radiation distribution curve and makes the total radiation *infinite*. This consequence, which the researches of Lord Rayleigh[22] and Jeans[23] made extremely probable, has been rendered certain by those of Lorentz.[24] According to the latter's researches, the most general equation of an electromagnetic system, based upon the ether, electrons, and matter, by a suitable choice of parameters can be reduced to the Hamiltonian form of the equations of mechanics. The application of the methods of probability and statistical mechanics, especially the theorem of Liouville (which is a consequence of the Hamiltonian form), leads us, then, to consider as applicable to the ether the theorem of the equipartition of energy which also brings us out with Rayleigh's formula.

In order to escape from this blind alley and obtain the earlier formula, Planck invented the hypothesis of the discontinuity of energy or quanta.[25] According to this hypothesis, the molecular resonators cannot exchange energy with the surrounding medium except in whole multiples of the same elementary quantity (quantum), $h\nu$, an amount proportional to the frequency of the resonator. The constant h would be a universal constant. We will not explain here the various forms given to the theory by Planck himself, Sommerfeld, Einstein, H. Poincaré, and others (see articles cited, foot-note 27). We will pass over all the consequences which have been deduced from this hypothesis (theory of specific heats by Einstein, etc.), except those which are purely electromagnetic.[26]

It appears that we need not give up for the free ether the equations and ordinary laws of electromagnetics or the dynamics of the free electron. The modification of the electromagnetic theory which we must make, if necessary, relates only to the relations between matter and the ether; that is to say, with regard to electrons not free, to emissions and absorption of energy, or perhaps to emission alone, which must then be considered as discontinuous.

Brillouin[27] thinks that there is a loophole of escape: Planck's theory rests upon an arbitrary hypothesis with regard to strictly monochromatic resonators having very little physical basis. In giving these up, the complication of the reasoning rapidly increases, but Brillouin thinks that we can probably come out with Planck's formula without recourse to quanta. The result would, however, be inconsistent with the general theory of Lorentz previously mentioned. Possibly we may hope to reach more precise knowledge of the mechanism of absorption about which we know practically nothing, and thence get a loophole for escape. This doubtless will happen in the future.

There is another domain than that of radiation, wherein the electronic and quanta theories are clearly inconsistent, that of the properties of the metals. According to the electronic theory, the thermal and electrical conductivities of the metals, as well as many other of their properties, are due to the motion of free electrons. We may, indeed, derive thus the law of Wiedemann and Franz. Electrons should therefore play an important part in the specific heats of the metals. But, according to the theory of quanta, the specific heat is uniquely related to the uncharged atomic resonators (Einstein). This accounts for the behavior of the specific heats at low temperatures. But the quanta theory has nothing to offer as to the thermal and electrical conductivities. The discordance is, however, decisive. It is perhaps premature to try to reconcile matters until measures of the thermal conductivities at low temperatures have been made, comparable with the excellent ones on the electrical conductivities made by Kamerlingh Onnes[28] at the temperature of liquid air and hydrogen.

IV. THE MAGNETON.

The electron seems to have definitely become one of our physical properties. P. Weiss[29] has for several years, and with increasing success, tried to introduce an element of magnetism, the magneton, bringing to bear upon it an imposing mass of experimental results.

He started from the theory of dia- and para-magnetism built by Langevin.[30] In that theory diamagnetism is explained by the deformation of the intra-atomic electronic trajectories under the influence of an exterior electric field paramagnetism results from the existence of a molecular magnetic moment of certain substances. Weiss has elaborated this theory so as to include ferromagnetism by means of a supplementary hypothesis, that of molecular magnetic fields proportional to the magnetizing force. This idea of an electric field is not new. Through it Ritz[31] developed his beautiful theory of the structure of the series of certain spectrum lines and the Zeeman effect. It led Weiss to formulæ which are well substantiated by experiment not only in the legitimate field of electromagnetism (the variation of the Curie constant with the temperature), but also as to the specific heats of ferromagnetic bodies. It was while looking for such precise experimental confirmation that Weiss was led to the theory of the magneton.

The measure of the absolute value of the atomic magnetic moments of iron and nickel at the temperature of liquid hydrogen, made in collaboration with Kamerlingh Onnes, led at the start to numbers 12,360 and 3,370, which divided, respectively, by 11 and 3 lead practically to the same quotient, 1,123.5. For cobalt the corresponding number was later found to be very close to $9 \times 1{,}123.5$. For the molecule of magnetite the results were more complex and must be divided by 3 to compare them with the atom of iron. These also led to whole multiples of the same number, the factor of proportionality changing abruptly at certain temperatures as if the atom of iron underwent corresponding alterations. The number 1,235, of which all the atomic magnetic moments are multiples, will be called the magneton-gramme, and its quotient by the Avogadro number (the number of atoms per gramme-atom) is the magneton, 16.4×10^{-22}. The properties of a ferromagnetic body are then well explained by supposing that the magnetic moments of their atoms are simple multiples of a magneton. Magnetism will then have a granular structure like electricity.

Interesting confirmations have been made of this theory through measures of various experimenters upon paramagnetic salts or, indeed, upon other bodies. The numbers of Pascal[32] and those of Mlle. Feytis[33] are in qualitative and quantitative accord with the hypothesis of the magneton. As these numbers were calculated with reference to water as a standard, an exact knowledge of the diamagnetic constant of water became necessary. Its measure is difficult and has led to discrepant results. It has been remeasured separately by Sève[34] and by P. Weiss and Piccard,[35] who have reached concordant results close to 0.72×10^{-6} at 20 deg. Cent. The theory of the magneton thus has had the merit of fixing definitely this important constant.

We are obliged to admit, however, that for ferromagnetic bodies the atom does not possess a unique magnetic moment, but has a certain number of different values according to the temperature and the chemical compound into which it enters. All these values, however, have integral ratios. The actual existence of the magneton has been demonstrated in the atoms of iron, nickel, cobalt, manganese, vanadium, calcium, mercury, and uranium. We therefore seem to have here a real, very general constituent element of matter. We may therefore think of adding the magneton to the other known fundamental elementary bodies. The attempt made by Langevin[36] to deduce the magneton from the quantum of Planck will doubtless serve as a stimulus in this direction.

IV. THE PRODUCTION AND NATURE OF GASEOUS IONS.

We will not discuss here the simple, ordinary ions such as originate from the X-rays, radium, the Hertz effect, etc. For several years the accepted theory (Langevin, J. J. Thomson, Townsend, and others) was this: the negative electron, torn from a molecule by the ionizing force, surrounds itself with a cortege of neutral molecules; the residual positive atomic ion does likewise. Thus originate the ordinary positive and negative ions. They are characterized by their mobility K, coefficient of recombination a, and diffusion D. At very low pressures and at high temperatures these assemblages are dissociated little by little to the primitive charged center. We will see that some modification of these ideas will be necessary.

(1) Along the line of theory since the fundamental work of Langevin (Annales Ch. Phys., 1905) several new attempts have been made to explain the order of magnitude of the mobilities and their variations. Among these we should specially mention those of Sutherland,[37] of Wellisch,[38] and of Reinganum.[39] Sutherland, especially, departing from the hypothesis of molecular agglomeration, supposes that an ion is identical with the electron or the primitive atom-ion; its velocity is modified and retarded by the electric action exercised upon the neighboring ions or the molecules polarized by its approach. An apparent viscosity is thus created which explains very well the results of Phillips (see further on) upon the variation of the mobility with the temperature. The actual theory is not unlike that which led Sutherland to his well-known formula for the variation with the temperature of the viscosity of a gas.

It will be perhaps convenient to use the conventions of the older theory, considering the ions as assemblages in perpetual process of formation and disintegration in a kind of dynamical equilibrium; the charged center will then be in turn free and loaded with neutral molecules. We will see that a greater part of the experimental data makes such a convention almost necessary.

(2) With a view to furnishing useful material for the theoretical developments, many measures have been made upon the mobility, the rate of recombination, and the diffusion at various temperatures and pressures. We will mention the measures of Phillips[40] (variation of k and a with the temperature), Kovarik,[41] Todd,[42]

[21] These laws rest only on the Doppler-Fizeau principle, thermodynamical reasoning, and the pressure of radiation, principles which may be held as well proven if not as experimental facts.

[22] Rayleigh, *Phil. Mag.*, vol. 2, p. 539, 1900.

[23] Jeans, *l. c.*, vol. 10, p. 91, 1905; vol. 17, p. 229, 1909; vol. 17, p. 773, 1909; vol. 18, p. 209, 1909.

[24] Lorentz, *Revue générale des Sciences*, p. 14, 1909; La théorie du rayonnement (The theory of radiation), Rapports au Congrès de Bruxelles de 1911, publiés par Langevin and de Broglie.

[25] See the recent article by J. Perrin in the *Revue* for November 15th, 1912.

[26] These consequences have been resumed in a notable course of lectures given this year at the Collège de France by Langevin.

[27] Brillouin, *Comptes Rendus*, vol. 156, pp. 124, 301, 1913.

[28] With regard to all these questions which we cannot stop to more than sketch, see the lecture which we delivered before the Société de physique in December, 1911, upon the electron theory of metals, and also the book which we have several times cited on the Theory of Radiation.

[29] Weiss, *Journal de physique*, pp. 900, 965, 1911.

[30] Langevin, *Annales de chimie et de physique*, vol. 5, p. 70, 1905.

[31] Ritz, *Annalen der Physik*, vol. 25, p. 660, 1908.

[32] Pascal, *Ann. Ch. Phys.*, vol. 16, p. 531, 1909; vol. 19, p. 5, 1910.

[33] Mlle. Feytis, *Comptes Rendus*, vol. 152, p. [illegible], 1911.

[34] Sève, *Ann. Ch. Phys.*, vol. 27, p. 189, 1912.

[35] Weiss and Piccard, *Comptes Rendus*, vol. 155, p. 1,234, 1912.

[36] Langevin, Rapport à la Conférence de Bruxelles, 1911.

[37] Sutherland, *Phil. Mag.*, vol. 18, p. 341, 1909.

[38] Wellisch, *Phil. Trans.*, vol. 209, p. [illegible], 1909.

[39] Reinganum, *Phys. Zeitschr.*, vol. 12, pp. 575 and 666, 1911.

[40] Phillips, *Proc. Roy. Soc.*, 1906, and vol. [illegible], p. [illegible], 1910.

[41] Kovarik, *Phys. Rev.*, vol. 30, p. 415, 1910; *Proc.*, vol. [illegible], p. 154, 1913.

[42] Todd, [illegible], p. 153, 1912; p. [illegible], 1913.

Dempster,[46] (variation of K at high and low pressures), Sales[47] (variation of D with the pressure). These measures show that ionic agglomerations disintegrate faster at low pressures and high temperatures in the case of negative ions and tend for both positive and negative ions to revert to the primitive state. This is in accord with the measures made upon flames by Moreau,[48] Lusby,[49] H. A. Wilson, and others.[50] The negative ions in flames appear to differ little from corpuscles and are scarcely loaded in their accidental encounters with molecules. The positive ion has a size of the order of magnitude of a free atom-ion and often appears to be formed of an hydrogen atom, more rarely of a metallic atom in certain flames colored by salts.

(3) It is mostly with ionisation at ordinary temperatures that the newer results have been obtained. The study of ionised gaseous mixtures was first undertaken by Blanc[51] and by Wellisch.[52] According to them an ion produced in a gas A and then transported into another gas B, assumes a mobility characteristic of the gas B. This agrees with the idea of temporary agglomerations constantly destroyed and built up again. Blanc carried out his experiment with ions formed in carbonic acid gas and then transported into air. Wellisch created his ions in CH_3I of CCl_4 and then transported them into hydrogen. According to him the ionisation in hydrogen is enormously increased by traces of CH_3I, whereas the mobility changes only slightly. It looks as if the heavily loaded molecules of CH_3I transfer their charges to the hydrogen molecules. This is a remarkable property belonging to certain ions. The same experimenters, as well as Lattey,[53] Tyndall,[54] and others, have studied with precision the influence of traces of a foreign gas upon the mobility of ions. According to Blanc, a small amount of aqueous vapor diminishes the mobility of the negative ion and increases that of the positive ion in air and in carbonic acid gas (450 and 490 C. G. S. for air instead of 380 and 600). The same occurs with alcohol vapor. The molecules of water and alcohol without doubt remain longer associated with the charged nucleus than those of air, carbonic acid gas, or hydrogen. Just the opposite is the case with the molecules of CH_3I, CCl_4 etc. From this we see also that in certain gases the positive ions finally surpass the negative ions in mobility. This, for instance, happens with chlorine.

The most remarkable fact in this connection was noted by Franck.[55] Working upon argon he found normal mobilities (of the order of 1 centimeter in a 1 volt-centimeter field) for the positive ions, while the negative ions had mobilities of more than 200 centimeters and behaved as corpuscles free from corteges of molecules during the major part of their courses in the gas. This enormous mobility diminishes very rapidly under the least trace of oxygen; it is brought down to 1.7 centimeters by 1.5 per cent of oxygen. The tendency to associate with the oxygen molecules is therefore much greater than with the argon atom. Nitrogen shows a behavior analogous to argon.

(4) The study of the charge carried by the ions has led also to important results. The method used for measuring the charge e is based upon the condensation of water-vapor upon the ions (Townsend and J. J. Thomson) and has been further perfected by Millikan[56] and his pupils. By means of a microscope a single drop of oil or other material charged by the ionised gas is observed between the horizontal plates of a condenser. Its rates of rise or fall due to the combined electrical and gravitational fields are followed, and from these rates the charge e may be computed. Thus by observing the sudden changes in the rates the new charges can be noted as they are added to or taken away from the drop. It is found that these modifications of the charge of the drop always occur in whole multiples of the same elementary charge, e. The mean of the numbers found for e was 4.80×10^{-10} electrostatic units. This number accords with that deduced by Rutherford from his measures with the rays, although J. Perrin found somewhat smaller values from his study of emulsions and of the Brownian movement.

An important fact was noted by Townsend[57] and his students: Ions of double charge, $2e$, or multiples of this, were found in ionised gases. This was noted in the experiments made in 1899, by means of which Townsend, measuring the diffusion coefficient D by a method using a gaseous current and comparing it with the mobility k was able to determine the product Ne of the charge of the ion by the Avogadro's number (the number of atoms per atom-gramme). This was a static method and permitted the evaluation directly of the quotient k/D which equals the product Ne. This result was dependent upon the method of ionisation used. At mean pressures and with the a rays from radium in air or the secondary rays due to X-rays produced upon polished brass in hydrogen or oxygen, slightly moist, ions of opposite sign were both found to give nearly the value 1.24×10^{10}. However, if the secondary rays are produced in air at a sheet of brass, oxidised or covered with vaseline, or in other gases (hydrogen, oxygen, carbonic acid) upon the same strip polished and covered with vaseline, the value of Ne is much greater for the positive ions. It may be found as high as 2.4×10^{10}. We conclude therefore first, that certain positive ions carry a charge $2e$; second, that such ions are produced by the more penetrating secondary rays which are not absorbed by the vaseline. The existence of the polyvalent ions has been confirmed by Franck and Westphal,[58] who returned to the older method, using a gaseous current and devised by Townsend, in which K and D are separately measured. With X-rays the proportion of polyvalent ions is about 1/10; with the a rays of polonium or the β rays of radium there seem to be no polyvalent ions. Millikan and Fletcher[59] do not agree with these conclusions, basing their objections upon the method of drops earlier described. But the earlier physicists maintain their interpretation, which also seems to be in good accord with the results from other methods (multiple charges of the a rays from radium, of the canal rays, the positive rays of vacuum tubes, according to J. J. Thomson, Gehrke, and Reichenheim and others).

However, the question must seem at present unsolved. Very recently, Langevin and Salles,[60] measuring the ratio K/D by a new direct method, have concluded against the existence of polyvalent ions in the ionization by X-rays. We must therefore still leave the question open.

(5) Finally, we must note the remarkable experiment by which C. T. K. Wilson[61] has enlightened us as to the mechanism of ionisation. Continuing his celebrated experiments on the condensation of water vapor on ions, he succeeded in *seeing and photographing the trail of ions*, produced in a gas by an angle a or β particle from radium or a very narrow pencil of X-rays.

His admirable photographs themselves alone can give an idea of all of which we can learn from them. Upon them we see the a and β particles following their rectilinear trajectories; we learn that the X-rays do not ionise directly but by the secondary rays which they tear from the molecules encountered in the gas, etc. We find also a direct verification of the hypothesis advanced by Langevin and put to experimental test by Moulin[62] in order to explain the "initial recombination" discovered by Bragg. According to the latter, the saturation current of a gas ionised by a rays is much more difficult to obtained than when X-rays are used. This is due, not to an "initial recombination" between the positive atom ions and electrons just liberated, but to a localisation of the ions along the path of the a particles; a saturation current is indeed much easier to obtain when the field is perpendicular to the radiation than when parallel.

VI. PHOTOELECTRIC EFFECT. (HERTZ AND LENARD EFFECTS.)

Light, and especially ultra-violet light, discharges negatively electrified bodies with the production of rays of the same nature as cathode rays. Under certain circumstances it can directly ionise gases. The first of these phenomena was discovered by Hertz and Hallwachs in 1887. The second was announced first by Lenard in 1900. Perhaps on no subject is the literature of the day greater and more contradictory, so we will note only a few of the recent results upon which the bulk of the work has been done.

(1) With regard to the Hertz effect, the researches from the start showed a great complexity of the phenomenon of photoelectric fatigue; that is, the progressive diminution of the effect observed upon fresh metallic surfaces. According to an important research by Hallwachs,[63] ozone plays an important part in the phenomenon. However, other elements enter such as oxidation, the humidity, the mode of polish of the surface, etc. We are not even sure that the fatigue is absent in a vacuum. Eugene Bloch[64] insists that we should work with an exciting radiation of definite wave-length since the fatigue varies from one wave-length to another. He also showed that in certain instances there is an acceleration of the effect which has been refound by various workers.

A great many experiments have been made in a vacuum. Some were undertaken to study the Hertz effect at the rear surface of a strip traversed by the light, an effect perhaps greater there than at the front surface (Stohlmann, Kleemann, and others). Other experimenters have shown a selective effect in the case of certain metals; for instance, with the alkaline metals, according to Pohl and Pringsheim,[65] there are maxima of exciting power at wave-length 0.300 μ for sodium, at 0.430 μ for potassium, and at 0.390 μ for a liquid alloy of potassium and sodium. The general exciting power increased regularly toward the smaller wave-lengths. Several workers have also endeavored to extend the photoelectric sensitiveness of photoelectric cells into the infra-red (Elster and Geitel) or to utilize them for photophony (Bloch).

However, the greatest effort has been spent in order to find out in vacuum the variation of the initial velocities of the photoelectric electrons with the wave-length. This problem has a great theoretical interest, and the simple laws stated by Lenard since 1900 for the ensemble of radiation emitted should be studied separately for each wave-length of the exciting radiation. According to Lenard, the total number of electrons emitted is proportional to the intensity of the incident light, but their velocity is independent of it, as well as of the wave-length for any given metal. This odd result does not at all agree with the quanta hypothesis which, according to Einstein, leads to a linear variation of the initial energy $mv^2/2$ with the frequency. We may further in our measures replace the initial velocity by the maximum positive potential V which the metal can take under the influence of the rays (that is, the potential of the stoppage of the electrons). The first measures made upon this matter by Ladenburg[66] showed an increase of the initial velocity with the exciting frequency. Taken up by Ladenburg and Markav,[67] Hull,[68] Hughes,[69] Richardson,[70] and others, the experiments have confirmed, although not without dispute and difficulty, the qualitative result of Ladenburg and apparently the theoretical law of variation due to Einstein. Certain writers contest this last deduction and claim a parabolic in place of a linear law of variation.[71] Our own unpublished experiments completed upon this question lead us to reserve our decision, because of the smallness of the ranges of wave-lengths studied by all these experimenters. It will be necessary to take up with quartz apparatus this question, working with the alkaline metals from the visible spectrum way up to the extreme ultra-violet. This is the only procedure which will allow a real experimental test of the theory of quanta. We will close with the results obtained by Millikan[72] and his pupils, who have found in certain cases abnormally high initial velocities. It looks as if there might be some experimental error due to the mode of production of the discharge by the ultra violet light and the influence of the electric waves from the source upon the measuring apparatus.

(2) The discovery of the ionization of gases by ultra-violet light was made by Lenard in 1900. As the effect was produced across several centimeters of air and made very great positive and small negative ions, it was natural to interpret the phenomenon, as did J. J. Thomson, as an Hertz effect upon the solid or liquid particles present in the gas. The researches of Langevin and those of Eugene Bloch[73] have shown, indeed, that the greater part of the Lenard effect is certainly due to this cause.

The Lenard effect upon the gas itself nevertheless does exist. Refound by J. J. Thomson[74] and then more decisively by Palmer,[75] it has already been considerably studied and shows very different characteristics than those at first attributed to it by Lenard. It seems to be produced exclusively by the Schumann or extreme ultra-violet rays of wave-length less than 0.180 μ. These rays

[46] Dempster, *Phys. Rev.*, vol. 34, p. 53, 1912.

[47] Sales, *Radium*, p. 59, 1911.

[48] Moreau, *Comptes Rendus*, vol. 148, p. 342, 1909; *Radium*, p. 70, 1910.

[49] Lusby, *Proc. Cambr.*, vol. 16, p. 26, 1911; *Phil Mag.*, vol. 22, p. 775, 1911.

[50] H. A. Wilson, *Phil. Mag.*, vol. 21, p. 711, 1911.

[51] Blanc, *Journal de physique*, vol. 7, p. 825, 1908.

[52] Wellisch, *Radium*, p. 241, 1909, and l. c.

[53] Lattey, *Proc. Roy. Soc.*, vol. 84, p. 173, 1910.

[54] Tyndall, *Nature*, vol. 84, p. 530, 1910.

[55] Franck, *Verh. Deutsch. Phys. Gesellsch.*, vol. 12, p. 291, 1910.

[56] Millikan, *Radium*, p. 345, 1910; *Phys. Rev.*, vol. 32, p. 349, 1911.

[57] Townsend, *Proc. Roy. Soc.*, vol. 80, p. 207, 1908; vol. 81, p. 464, 1908; vol. 85, p. 25, 1911; Haselfoot, *Proc. Roy. Soc.*, vol. 82, p. 18, 1909.

[58] Franck and Westphal, *Verh. der Deutsch. Phys. Ges.*, vol. 11, pp. 146 and 276, 1909.

[59] Millikan and Fletcher, *Phys. Rev.*, vol. 32, p. 239, 1911, and *Phil. Mag.*, vol. 21, p. 753, 1911. See also Townsend, *Phil. Mag.*, vol. 22, p. 204, 1911; Franck and Westphal, *Phil. Mag.*, vol. 22, p. 547, 1911.

[60] Langevin and Salles, Société de chimie physique, February, 1913.

[61] Wilson, *Proc. Roy. Soc.*, vol. 85, p. 285, 1911; *Radium*, January, 1912.

[62] Moulin, *Radium*, p. 350, 1910.

[63] Hallwachs, *Annalen der Physik*, vol. 23, p. 459, 1907.

[64] Bloch, *Radium*, vol. 23, p. 125, 1910.

[65] Pohl and Pringsheim, *Verh. der Deutsch. Phys. Ges.*, vol. 12, pp. 215, 349, 1910.

[66] Ladenburg, *Phys. Zeitschr.*, vol. 8, p. 590, 1907.

[67] Ladenburg and Markav, *Phys. Zeitschr.*, vol. 9, p. 821, 1908.

[68] Hall, *Phys. Zeitschr.*, vol. 10, p. 537.

[69] Hughes, *Phil. Mag.*, vol. 21, p. 393, 1911; *Proc. Cambr.*, vol. 16, p. 167, 1911.

[70] Richardson, *Phil. Mag.*, vol. 24, pp. 570, 575, 1912.

[71] Kunz, Cornelius, *Phys. Review*, 1910 and 1913.

[72] Millikan and Wright, *Phys. Review*, January and February, 1911.

[73] Bloch, *Radium*, p. 240, 1908.

[74] Thomson, *Proc. Cambr.*, vol. 14, p. 417, 1907.

[75] Palmer, *Nature*, vol. 77, p. 582, 1908; *Phys. Rev.*, p. 1, 1911.

will not pass through air, although they will through fluorite and partly through quartz. It produces small ions of both signs, neutral centers, large ions, and ozone. It is extremely sensitive to minute traces of impurities in the gas, traces which cannot be detected by other means. It can be distinguished from the Hertz effect and become very much greater. All these conclusions are drawn from the researches of Hughes,[16] Cannegieter,[17] Lenard and Ramsauer,[18] and Léon and Eugene Bloch.[19] The latter have shown also that the radiation transmitted by quartz and coming from a mercury arc ionizes the air feebly in the neighborhood of the arc and seems consequently to omit a small amount of Schumann rays. In place of the usual source of Schumann rays, a hydrogen tube furnished with quartz windows, Lenard and Ramsauer used a very powerful spark between electrodes of aluminium. Then the ionization takes place even through air and quartz and the experimentors attribute it to rays of wave-length less than 0.1 $\mu\mu$, the smallest ultra-violet rays known, and which were discovered by Lyman. As no measure of these wave-lengths was made, it seems as probable that the effect is due to ordinary Schumann rays which have been partially transmitted by media generally opaque to them because of the great original intensity of the light. This question remains to be studied as well as the Lenard effect in general, the knowledge of which is yet very limited despite the great number of interesting problems connected with it.

The Problem of the High Building

By Prof. Charles Peck Warren, Assistant Professor of Architecture, Columbia University

The question is frequently asked, Will America ever develop a style of architecture? Probably the nearest we have come to it is in the erection of the skyscraper - the most striking and characteristic feature of American architecture although this is but a step in the development.

The demand for the skyscraper is an outcome of conditions peculiar to New York, although Chicago claims the honor of having erected the first steel skeleton building. Manhattan Island is so narrow and its trade center is so near one end that the rapid increase in trade since 1870 has necessarily been confined to a limited area, and in consequence the land there has advanced rapidly in value.

The first direct result of the menace in the height of buildings was the invention of passenger elevators for commercial buildings, for it was soon discovered that tenants would not mount stairs above four, or, at the most, five stories. Elevators were employed for the first time in the Fifth Avenue Hotel in 1859, and later on, in 1868, in the old Equitable Building, destroyed by fire in 1911. The gradual development and improvement in high speed made vertical travel easy and comfortable, and the erection of six, then seven, eight, and finally nine-story buildings became possible. So that the problem of making downtown real estate investments profitable was thus temporarily solved.

As years went on, however, even nine-story buildings in which the cheapest offices rented for $2 per square foot of floor space ceased to yield sufficient revenue, owing to the constant rise in real estate values, so that the height of buildings had to be raised to ten and twelve stories. It was soon discovered that these tall buildings, constructed as they were of combustible materials in the floors, stairs, and elevator wells, could not be controlled in case of fire, so the Building Department in 1882 passed a law requiring buildings exceeding eighty-five feet in height to be fireproof.

This gave a great impetus to steel construction, and buildings such as the Mills, Morse, and Post were erected, in which, for the first time, the floor beams and interior columns were made of iron or steel. The further development of steel construction made it possible to erect a safe and economical building rising to a greater height.

A new difficulty here presented itself. Under the old system of construction the outer walls became so thick at the base, when the building was carried up twelve or fifteen stories, as to cause a loss of income to the owner, as, on a narrow lot, little more than an entrance hallway would be left. It became necessary to make the walls thinner, and this resulted in the construction of curtain walls and skeleton frames.

The masonry walls are not needed for strength; they are divided into sections and supported by the steel frame. A twelve-story building, for instance, would require 36-inch bearing walls on the first floor, but only 20-inch skeleton walls, saving nearly three feet in the width of the building, or over 10 per cent on a lot 25 feet wide. The walls of the Woolworth Building are 4 feet 4 inches thick at the base. Under the old method they would have been 10 feet 4 inches.

What is the limit to the height of buildings? The answer is the height at which the building ceases to yield a sufficient income on the investment. There is no doubt of the possibility of erecting a building 1,000 feet high—say, seventy-five stories—but would it pay?

An examination of the records of the Building Bureau shows that the increase in the height of buildings is not represented by a steady upward line of growth, but by an irregular line in which the upward tendency is interrupted at intervals by lines of depression.

Starting with the year 1890, which marked the beginning of the development of the steel skyscraper, the height rapidly increased to eighteen stories, reached by the Mutual Life Insurance Building in 1892. Then followed a reduction lasting two or three years, and then an upward movement culminating in 1890 in the twenty-four-story Park Row Building. The following decade witnessed a slight repression until about 1900, and then a rapid turn upward to forty-two stories attained by the Singer Building in 1908. Another ebb followed, and then a rise which was topped in 1912 by the Woolworth Building with its fifty-five stories.

A congestion of skyscrapers in any community is objectionable for several reasons; it is dangerous to life, menace to health, and it impedes traffic. It is quite true that the modern building can be made fireproof, but when filled with inflammable material, it becomes, in effect, merely a stove or a furnace in case of fire. A large percentage of so-called loft buildings are used for manufacturing purposes, for which they were not designed. Under the present building code it is still possible for owners to pervert the uses of their buildings. When the new code is adopted the provision requiring a certificate of occupancy to be filed with the plans will operate to prevent this condition.

In regard to the second cause, the dark rooms in which thousands must work, cut off from light and air by the adjoining tall buildings unquestionably have a damaging effect upon the health of the occupants. This, however, might not have any effect in limiting the height of buildings, but the fact that these darkened lower floors yield a smaller revenue will have its effect.

Concerning the third cause, it does not need any elaborate explanation to show that tall buildings bring about a thoroughly undesirable congestion of population. Start to walk up Fifth Avenue from Fourteenth Street any day at the noon hour. It is almost impossible, because of the tremendous outpouring of the occupants of the adjoining loft buildings. The result is the neighborhood is shunned, and shops become undesirable, rent falls and the buildings fail to return a proper percentage of profit on the land. When this happens either the building must be torn down and be replaced by a more remunerative one or land values will decrease.

The future uncertainty of land values in New York city will also have a tendency to discourage the erection of high buildings. Hitherto the tendency of values has been almost uniformly upward, but in the last few years there has been in some quarters, notably in the Broadway section above City Hall up and in lower Fifth Avenue, a tendency in the opposite direction. Who can foretell with any certainty the effect of the future subways and tunnels upon land values? Suppose the vast outlying area should be developed for manufacturing purposes, of what use would be the loft building?

A skyscraper is not necessarily a money-making investment. The majority return rents less than many other forms of investment, and some of them actually lose money. It is a sad commentary on the life of a skyscraper that the first, the Tower Building, 52 Broadway, erected in 1888, was torn down in 1913. Why? Because it did not pay, and on its site is being erected a low arcade stone structure equivalent in height to the average four-story building.—*New York Times.*

[16] Hughes, *Proc. Cambr.*, vol. 15, p. 483, 1910.

[17] Cannegieter, *Proc. Amst.*, p. 1,114, 1911.

[18] Lenard and Ramsauer, Sitzungsber. Heidelberg, 1910-1911.

[19] Léon and Eugene Bloch, *Comptes Rendus*, vol. 155, pp. 903, 1,076, 1912.

New Instruments of Precision

The work of Dr. W. Rosenhain, F.R.S., of the National Physical Laboratory, is very well known to engineers, particularly through his clear and comprehensive reports to the Alloys Research Committee of the Institution of Mechanical Engineers. Besides being a scientist of international repute Dr. Rosenhain is an inventor, and three of his latest instruments are described in his recent Institute of Metals paper on "Some Appliances for Metallographic Research." All three were worked out in the metallurgy department of the National Physical Laboratory in order to increase the accuracy and convenience of research work of the highest kind. The simplest is a little optical device for the accurate leveling of metal specimens for the microscope. A beam of light, reflected from the polished surface of the metal, is used as an index whereby the surface can be quickly and easily set truly horizontal. The other two instruments deal with problems which arise in the preparation of accurate cooling and heating curves. One of these problems is that of heating and cooling specimens of metal at any desired rate which shall remain constant over a wide range of temperatures. This is attained by the use of vertical tube furnaces so arranged as to be hot at one end and cold at the other, with a uniform gradation of temperature between the two ends. The specimen is raised or lowered in this tube, and is heated or cooled accordingly, the rate being easily varied by altering the rate of raising or lowering. A "blank" heating curve reproduced in the paper shows a maximum variation for 2 deg. Cent. ranging only between 12 seconds and 20 seconds over a temperature range of 700 deg. Cent.

The third appliance described, says the *London Daily Telegraph*, is a "plotting chronograph," by means of which the "inverse rate" curves, so freely used in metallographic research, are plotted automatically to a very large scale, the observer merely tapping a key as the various temperature intervals are passed. The instrument, which thus not only acts as a chronograph, but at once plots the readings in the shape of a curve, is somewhat complex. Its accurate and satisfactory working, however, is testified by the curves with which the paper is illustrated.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JUNE 5th, 1915

Published weekly by Munn & Company, Incorporated
Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer
all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

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Scientific American (established 1845)	"	3.00
American Homes and Gardens	"	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application

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SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXIX
NUMBER 2058

NEW YORK, JUNE 12, 1915

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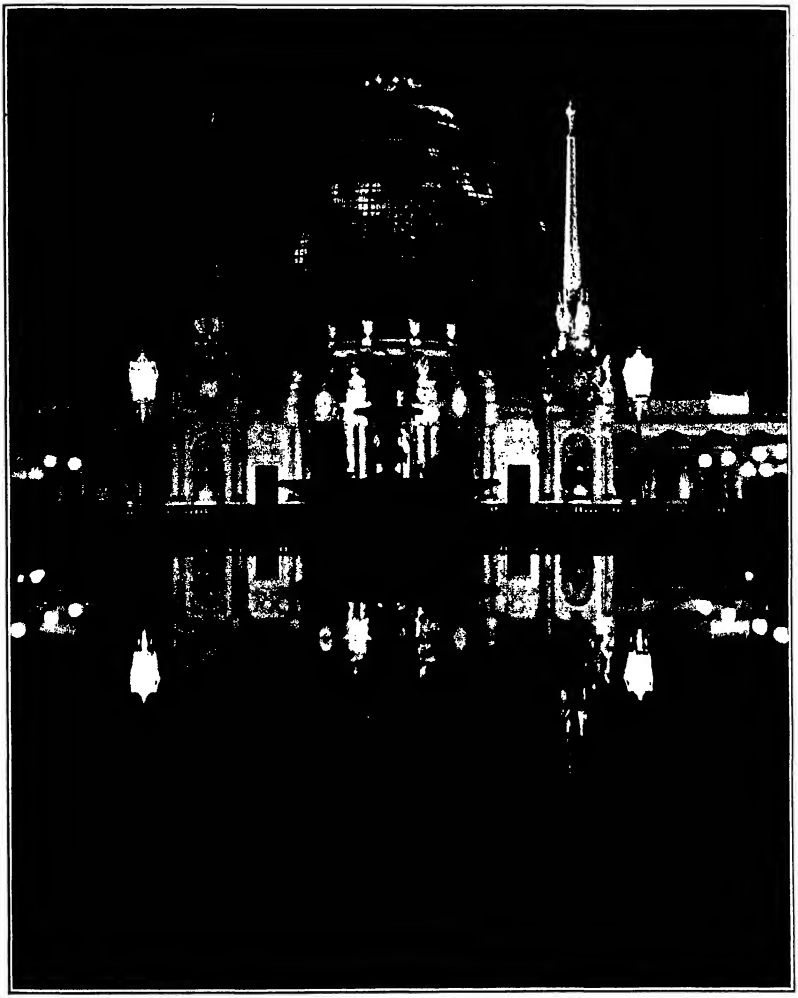
$5.00 A YEAR



The Palace of Horticulture at night. The great glass dome is illuminated by hanging colored lights projected from within.

THE ILLUMINATION OF THE PANAMA-PACIFIC EXPOSITION.—[See page 376.]

The Future of Science

What New Discoveries Are Possible and Which Will Be Most Desirable

In December, 1913, many French and a few foreign men of science were invited by *Le Temps*, of Paris, to indicate the discoveries possible in the actual state of science, which they regarded as most useful, and also those which were most eagerly awaited in various branches of science.

Summaries of the most interesting replies are given below:

Prof. Emile Picard: This distinguished mathematician reminds his questioner that very useful discoveries do not always win contemporary appreciation. The Greek geometers, whose work still affects astronomy and navigation, were not famous in their day, and Sadi Carnot's classical memoir on "the motive power of fire," was ignored for 20 years. How, then, can we predict which new discoveries will be most useful?

In applied science the circumstances are somewhat different, and there can be no doubt that the discoveries most impatiently awaited are those which pertain to disease and old age. The fountain of youth and vaccines for all diseases are universally desired.

In moral science, a remedy for social and international hatred, which appears to increase daily, would be a fine discovery.

Prof. Yves Delage: This eminent biologist, whose sight has been almost destroyed by his work on artificial fertilization of sea urchins' eggs, regards the adaptation of species to their conditions of existence as the great riddle of biology. This undeniable fact seems explicable only by the heredity of individual modifications due to environment, but this heredity has not been demonstrated and apparently does not exist. The problem, therefore, is to discover either the hidden way by which these modifications are transmitted to descendants, or some method of evolution that can dispense with such transmission. Many attempts have been made in both directions, but no satisfying solution has been reached.

Another desideratum is convincing proof of the generally accepted hypothesis that the chromosomes maintain their individuality through generations of cells and organisms and that their substance is the sole material substratum of cell properties and hereditary characters.

Prof. E. B. Baillaud, director of the Paris Observatory: Prof. Baillaud indicates several promising astronomical researches.

The Swedish astronomer Sundmann has solved the celebrated problem of three bodies, but his solution seems numerically inapplicable. It may be possible to find other solutions applicable to the complete study of planetary motions.

Solar radiation possesses the highest interest, because it affects meteorology, agriculture, hygiene and all vital phenomena. So much has been learned, in the past 20 years, concerning the variations of solar radiation that it is not too rash to predict that the study will be completed within a few decades.

The constitution of the stellar universe presents a fascinating problem. The monumental star catalogues undertaken last century are nearing completion and the distribution of the stars over the celestial vault is very accurately known. By studying the parallax, proper motion and brightness of a great number of stars we can determine their distribution in space, and learn whether the visible stellar universe is of finite or infinite extent. Results full of promise have been obtained in the past 15 years.

Not less interesting is the quest of the elements that fill interstellar space, which contains swarms of meteors, countless stars surrounded by gaseous atmospheres, and nebulæ as big as constellations. The earth receives only a few minerals from the meteors that it encounters, but we know not what may be added to its atmosphere by the nebulæ that it traverses.

Exact knowledge of the form and dimensions of the earth, and their variations, is also desirable. It is now possible to undertake a study of gravity, longitudes, latitudes and their variations that may explain the causes of those variations and the constitution of the earth itself.

Prof. Svante Arrhenius: The famous Swedish astronomical physicist who devised a new cosmogony and a theory of interstellar dissemination of organic germs by the force of radiation (panspermy) briefly expresses his opinion that now, after the enormous recent advances in physics and chemistry, the time has come to solve, with the aid of the knowledge thus acquired, those biological and medical problems that are most important for the future of humanity.

Dr. E. Grasset expresses, still more briefly, a similar opinion: that tuberculosis and cancer are the two great problems, the solution of which is universally desired.

Prof. Charles Moureu: This well-known chemist sent a very long contribution, inspired by his diligent study of radioactivity and the rare gases of thermal springs. After describing radioactive disintegration and the electron theory of atoms, and conceding that no method of accelerating, retarding or otherwise affecting radioactive changes has yet been discovered, he asks if we shall be content to remain in this state of impotence, and cites, in illustration, the artificial synthesis of many organic compounds, for the formation of which a mysterious "vital force" was formerly deemed necessary.

Two problems are presented: to stimulate the spontaneous disintegration of the instable radioactive atoms, and to destroy the stability of the atoms of other elements. All attempts to influence radioactive phenomena by means of very high or low temperatures have failed. Perhaps the employment of very high or low pressures would be more successful. The known radioactive elements are the elements of highest atomic weight, and the current theories of the evolution of matter and worlds assume that heavier and heavier atoms come successively into being as the pressure increases.

On the other hand, electric discharges in highly rarefied gases produce electrified particles which can come only from atomic disintegration. Röntgen rays and radium rays produce analogous results in the ionization of gases. Electrified particles are emitted, also, by negatively electrified metals exposed to ultraviolet rays. One of these ways may lead to the goal.

Magnetic force, however, seems peculiarly fit for the task of destroying the electro-magnetic equilibrium of the atom. The maximum magnetic force yet developed, 50,000 gausses, has proven insufficient, but a force ten times as great might shatter the structure and produce new atoms of known or unknown kinds from the fragments. The vast possibilities thus suggested lead Prof. Moureu into speculations which it would be futile to follow.

Prof. Armand Gautier: Prof. Gautier, whose researches on nutrition, toxins and the living cell have become classical, likewise regards the capture of radioactive energy as the most important object. A gramme of radium generates in one hour sufficient heat to raise the temperature of one gramme of water from the freezing to the boiling point. Hence, as the life of radium is 2,500 years, one gramme must possess more than a million calories of convertible energy.

If this is energy of rotation the capture of part of it does not seem impossible. When two rapidly spinning billiard balls come gently into contact their energy of rotation is suddenly converted into energy of translation, and they are projected with great velocity in opposite directions. It may be possible to realize this with atoms.

Sir Edwin Ray Lankester: This eminent English physician replied that scientific researches should not be undertaken for utilitarian ends, but should be inspired solely by the desire to increase human knowledge. The exploitation of science by industry and the self-advertisement of so-called scientific benefactors do not further the progress of science. In order to know which researches are most desirable it is necessary to study the question systematically. The future of science is a secret that can be understood only by those who approach it by the way of study.

Charles Nordmann: This young astronomer of the Paris Observatory, the inventor of an ingenious instrument for measuring star temperatures, begins by discriminating between two meanings of the word "useful." The most useful discoveries, in the customary sense, would be discoveries leading to the conquest of tuberculosis, cancer and other diseases, or to the industrial exploitations of natural sources of energy, including solar radiation, atomic energy and tidal energy, which probably will be the first to be utilized.

In another sense, however, nothing seems more useful or more desirable than the solution of problems concerning the nature of things. For example, are all vital phenomena reducible to physical and chemical processes? An affirmative answer would not supplant mysticism by pure materialism, for physical and chemical forces are mysterious in themselves, but it would entail the possibility of producing artificially, in the fulness of time, living creatures endowed with any desired qualities, physical and mental.

Another problem of acute interest concerns the relations between matter and ether, and the way of escape from the labyrinth of contradictions to which the principle of relativity leads.

And nothing, perhaps, would be more useful or more important for the future of mankind than the discovery of unfailing methods of selecting and educating those children who are capable of becoming geniuses.

Prof. Henry Le Chatelier thinks that researches on the intimate constitution of matter are desired by the majority of chemists, but declares his own preference for the general diffusion of the methods, as distinguished from the results of science, and the application of these methods to everyday affairs. He cites the scientific organization of metallurgical work achieved by the American engineer F. W. Taylor, through the application of scientific methods to the psychology of the workers (a system which Prof. Le Chatelier has introduced in France), and also mentions "The New Housekeeping," a book on the scientific organization of the home, written by an American woman, Mrs. Christine Fredericks.

Prof. Pierre Puiseux: This distinguished selenographer of the Paris Observatory, after stating that the most useful and desirable discoveries are those most beset with difficulties, indicates two lines of research that seem at once important and promising. One aims at the capture of atomic energy, the other at the artificial reproduction of stellar spectra.

Although 12,000 of the 20,000 dark lines in the spectra of the sun and most stars do not correspond to bright lines in laboratory spectra of known elements, there is good reason to believe that they are due to known elements, in physical conditions that we have not yet been able to imitate. This belief has become stronger since we have learned that light is modified by electric and magnetic influences, and that metallic vapors can become fluorescent, and emit waves differing in length from the incident waves. A group of stellar lines that had long been an enigma has recently been reproduced in the laboratory with a mixture of hydrogen and helium.

But there are stars, and especially nebulæ, which give a spectrum composed of bright lines, only a few of which correspond to the lines of hydrogen. The distribution of the lines indicates that they may be due to a single element, of very complex atomic constitution. In the laboratory this may reveal itself either as a new element, or as a known element in a peculiar state. The discovery would greatly clarify our notions of the structure and history of nebulæ.

Prof. Gustave Le Bon: Prof. Le Bon devotes the greater part of his letter to his claim of priority in the conception of spontaneous atomic disintegration. In his opinion, however, the possibility of utilizing the energy liberated by the artificial disintegration of atoms, if this could be accomplished, is doubtful, because it is to be feared that the expenditure of an equal amount of energy would be required to effect the liberation. For the same reason the transmutation of elements possesses no practical value, although its theoretical interest is very great.

Prof. J. Hadamard: This eminent mathematician replies that it is very difficult to predict the ways in which science will advance, and absurd to choose between them. The tendency toward the unification of science is the essential thing.

Dr. Arnold Netter: Dr. Netter, who introduced in France the Wassermann-Flexner serum for cerebro-spinal meningitis, predicts great progress in various departments of medicine and surgery, including serum therapy, organo therapy, transfusion of blood, suture of organs, and the study of the effects of mineral agents, including those which, like arsenic, iodine and fluorine, are found in the body in infinitesimal quantities. The great advances made in these fields in recent years have been due to the collaboration of men of all nations. This collaboration will continue and will create a foundation for universal peace.

Prof. Gaucher: Dr. Gaucher, likewise confining his reply to the medical field, says that every effort should be devoted to the conquest of tuberculosis, the most formidable of all human maladies.

Prince Albert of Monaco: Prince Albert, the creator of the new science of oceanography, regards as especially desirable such discoveries in paleontology as will throw light upon the history of humanity and will make anthropology a guide in philosophy and ethics. If human judgment were based on exact knowledge of the place which human history occupies in the history of the organic world, the barbarism that still remains in communities professing to be civilized would be more easily conquered. When it shall have been proved that the human race necessarily follows the path traced by the forces which produce its central faculties, we shall know better how to accomplish social progress.

The preservation of living species is as important as the collection and preservation of remains of extinct species.

Prof. Gaston Bonnier: Prof. Bonnier, who has made extensive researches on the changes produced in plants by changes in their environment, emphasizes the importance of the problem of evolution of species. M.

naturalists of the present day are transformists, in that they believe that a species can be transformed into a different species by external or internal influences, but they do not agree in regard to the mechanism of the transformation, and the fact is not proved. Experiments with plants have already given results that appear to confirm Lamark's view, that the forms and functions of organs are modified chiefly by changes in external conditions of life.

Prof. Paul Sabatier: Prof. Sabatier, who in 1912 shared with Prof. Gregnard the Nobel prize for chemistry, hopes for the speedy discovery or production of large quantities of radioactive substances.

Prof. Samuel Pozzi: Dr. Pozzi replies that exact knowledge of the cause of cancer is a most urgent desideratum. Neither the parasitic nor the non-parasitic theory has been proved conclusively, although the latter is perhaps supported by the stronger evidence, including results obtained recently by Dr. Pozzi.

The discovery of the parasite would soon be followed by the production of a diagnostic serum which would lead to very early operation. It might even be possible to produce a curative serum, that would diminish the extent and danger of the operation, which would still be necessary in Dr. Pozzi's opinion.

If the disease is not parasitic, knowledge of the conditions that promote the growth of cancer cells would suggest methods of preventing the disease, or, at least, of arresting or retarding its progress.

Prof. Emile Borel: Emile Borel, professor of the theory of functions at the Sorbonne, and an adept in the theory of probabilities, thinks that the scientific revolution has already been inaugurated by the application of the statistical method, notably to radioactive changes, which we can explain in no other manner. The sudden explosion of a single one of a multitude of radium atoms is governed by the known laws of probability. The point of departure for the science of the twentieth century is the principle that the most immutable laws are based on chance. The explanation of phenomena will consist in their reduction to very numerous elementary actions, regulated by statistical laws, as the pressure of gases is explained in the kinetic theory of gases. The most attractive problem is the statistical explanation of universal gravitation. When the statistical method has taken its proper place in mechanics and physics, it will be possible to apply it with advantage to biological and social problems. It is already recognized that the mysteries of heredity can be explained in no other way. This transformation of science will influence our conception of knowledge. The dogmatic value of a law like that of Newton will give place to the practical demonstration of the improbability of miracles, and statistical certainty will be substituted for logical certainty.

Prof. E. C. Pickering, of Harvard: This eminent American astronomer regards as the most important of astronomical discoveries the determination of the numbers of stars of different colors and degrees of brightness, for the purpose of finding their distribution in space and fixing the limits—of these are limits—of the stellar universe. Determinations of parallax and proper motion would be equally interesting.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Safe and Unsafe Oxy-Acetylene Generators

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In a recent issue of the SUPPLEMENT there was published a description of how to make an oxy-acetylene welding outfit, and while the writer is undoubtedly a clever mechanic, it is evident that there are many peculiarities of acetylene and facts in relation to its practical use that he is unacquainted with. As a consequence, the apparatus which he describes contains elements of serious danger, and it is of a form that meets the disapproval of all experts and experienced men.

In view of the above a few facts in relation to acetylene may be not only of interest, but particularly valuable to those contemplating the use of welding apparatus.

After the acetylene industry, which for the first few years gave especial attention to illumination, had developed the lighting generator to a point where it was so well safe-guarded that the National Board of Fire Underwriters pronounced acetylene illumination safer than the systems which it chiefly replaced, the great possibilities of oxy-acetylene autogenous welding became known.

Any new utilization of chemical elements brings to the surface new problems to be solved, and the rapid development of the oxy-acetylene welding process brought to the acetylene industry the necessity of a good many changes, among these the development of modifications in the system of generation. The details of the rapid adaptation of the industry to this new field only have interest to the general public, in so far as it may now be said that this field is as well covered as regards safety as the systems used for illumination.

The simplicity of the reaction between calcium carbide and water in the early days tempted many who are not engineers or chemists to bring about this reaction, and because they got illumination as a result, they did not realize that acetylene, like any other gas, must be properly controlled or it will cause trouble. So in the oxy-acetylene welding field engineers and mechanics not familiar with acetylene sought to simplify the systems of generation, and this has led to an epidemic of plans and specifications for simple generators, put forth in good faith by their originators, but hazardous in the extreme because the necessary safeguards, which long experience has demonstrated to be necessary, were entirely lacking.

The form which has seemed to be most attractive to these amateur designers has been the pressure generator, the basic idea being the mixture of carbide and water in such a way as to produce the gas under pressure, utilizing this pressure at the blow-pipe. Kitchen boilers are a favorite means of storing acetylene under pressure, or storing oxygen under pressure, or, many times, both in the same apparatus. The absence in the general markets of apparatus of this kind has led those uninitiated to believe that no one else has thought of this plan, and that a large field was open to the inventor who discovered it. The facts are that almost everyone in the industry has at some time passed through the stage of evolution where this idea has occurred to them, and the fact that no apparatus of this kind is to be had in the market should be a warning instead of an encouragement.

Acetylene under pressure changes its physical nature. After it reaches 15 pounds to the square inch, it gradually becomes more and more apt to dissociate without the addition of oxygen. The word "dissociate" as applied to acetylene means that the acetylene, which is composed of carbon and hydrogen, will, under certain circumstances, separate and cease to be acetylene but become carbon in the form of lampblack and hydrogen in the form of a gas. In doing so, it will give off considerable quantities of heat. The atoms therefore fly apart with explosive violence. If acetylene is not under pressure, the molecule which dissociates is too far removed from its neighbor to cause the next molecule to break up, but once you compress acetylene, the molecules come close enough together so that one molecule sets off the next, so that the whole mass goes instantly and with great violence. All that is needed to start the explosion is a temperature of 539 deg. Fahr. or above this. One of the best illustrations of this is a row of dominoes; assuming that you set your dominos three inches apart and knock over the first, the second one will not fall, the row of dominos will stand except the one which has fallen over, but if you bring the dominos close enough together so that one falling hits the next, the whole row goes off. So it is with acetylene—so long as the acetylene pressure is less than 15 pounds to the square inch, it may be subjected to high temperatures without dissociating except molecule by molecule, but if you compress above 15 pounds to the square inch, the danger point has been attained, and the more you compress the more dangerous it becomes. It is for this reason that free acetylene above 15 pounds to the square inch is forbidden all over the world.

The moment that this point is understood, it becomes apparent that what is known as the pressure generator would not be permitted for use by any authorities, municipal, State or insurance, if all the inspectors understood the matter. It is sufficiently understood so that these generators have never attained any large sale, and there is really no market for them that can be made profitable by anybody. There are a few concerns in the country who are pushing these generators. They are made not only for the oxy-acetylene industry, but they are used to create a pressure in acetylene which may be utilized in charging automobile cylinders. The use of pressure generators for this purpose has been followed by a record of death and destruction which should be sufficient warning. Nevertheless, there are certain people who, knowing the circumstances, still persist in endeavoring to foist pressure generators upon the local garage man or some inexperienced persons who may be induced to organize a little company for the purpose of filling automobile cylinders or welding. Widespread attention should be called by the scientific journals to the facts in the case and mechanics and others who are experimenting with acetylene should be warned not to undertake the compression of acetylene by any means, above 15 pounds to the square inch.

Numerous manufacturers are making generators working up to but not over 15 pounds pressure, which have passed the National Board of Fire Underwriters. These are properly safeguarded, and there is no reason why those desiring to enter the oxy-acetylene field should not secure a proper generator rather than risk their lives by using experimental systems of generation, which may be economical, but which contain inherent hazards which have not yet been overcome.

A. Cressy Morrison,
Secretary International Acetylene Association.

A Curious Property of Numbers

WRITE any number of three digits, of which the first is greater than the last, say 170
Interchange the first and last digits 071
Subtract
———
099
Considering this difference to be also a number of three digits, interchange its first and last digits 990
Add this number to the preceding
———
The result will always be . . . 1089

Another example:

582
285
———
297
792
———
1089

This rule is a particular instance of a general rule, obtained from the above by putting "two or more" for "three," the result being for a number of

2 digits	$9\times 11 = 9\times 11\times 1$	$= 99\times 1$	$=$	99
3 digits	$9\times 121 = 9\times 11\times 11$	$= 99\times 11$	$=$	1089
4 digits	$9\times 1221 = 9\times 11\times 111$	$= 99\times 111$	$=$	10989
5 digits	$9\times 12221 = 9\times 11\times 1111$	$= 99\times 1111$	$=$	109989

For a number of n digits ($n>1$) the result is 9 times a number of n digits, of which the first and last are 1's and the others, if there are any, are 2's; or 99 times a number of $n-1$ digits, all of which are 1's; or, if $n=2$, the result is 99, if $n>2$, the result is a number of $n+1$ digits, of which the first two are 1, 0, the last two 8, 9, and the others, if there are any, are all 9's. Also, if $n=3$, we note that the result is $3^2\times 11^2$, or 33^2.

We will prove the rule for the case when $n=3$. The general proof is similar.

Let m be the given number and a, b, c its digits, of which $a>c$.

Then $m=a\times 10^2+b\times 10+c$.

Let m' be the number obtained from m by interchanging the first and last digits.

Then $m'=c\times 10^2+b\times 10+a$.

Now when we proceed to subtract in the units column, since $a>c$, we add 10 units to the minuend and, to balance this, add 1 ten to the subtrahend, so that

$$m+10=a\times 10^2+b\times 10+(10+c)$$

and $$m'+10=c\times 10^2+(b+1)\times 10+a.$$

Then as we cannot take $b+1$ tens from b tens, we add 10 tens to the minuend and 1 hundred to the subtrahend, so that now we have

$$m+10+100=a\times 10^2+(10+b)\times 10+(10+c)$$

and $$m'+10+100=(c+1)\times 10^2+(b+1)\times 10+a.$$

Subtracting we get

$$m-m'=[(a-c)-1]\times 10^2+9\times 10+[10-(a-c)]$$

Since a and c are digits and $a>c$,

$$0\leqq c<a\leqq 9$$

Hence $$1\leqq a-c\leqq 9$$

Hence $$0\leqq (a-c)-1\leqq 8 \text{ and } 1\leqq 10-(a-c)\leqq 9$$

Therefore $(a-c)-1$, 9, and $10-(a-c)$ are the digits of the difference $m-m'$.

Set $r=(a-c)-1$ and $s=10-(a-c)$

Then $r+s=9$ and $m-m'=r\times 10^2+9\times 10+s$

Hence $$(m-m')'=s\times 10^2+9\times 10+r$$

Therefore

$$\begin{aligned}(m-m')+(m-m')' &= (r+s)\times 10^2+2\times 9\times 10+(s+r)\\ &= 9\times 10^2+2\times 9\times 10+9\\ &= 9(1\times 10^2+2\times 10+1)\\ &= 9\times 121\end{aligned}$$

In a two or three figure number interchanging the first and last digits is the same as reversing the order of all the digits. This is not so in general for a number of more than three figures.

For such numbers, however, special rules can easily be worked out for the result of an operation like that explained above in which we reverse the order of all the digits instead of merely interchanging the first and last digits.

For example, starting with a four figure number $a\,b\,c\,d$,
if $a>d$ and $b>c$, the result is 10890;
if $a>d$ and $b<c$, the result is 9999.

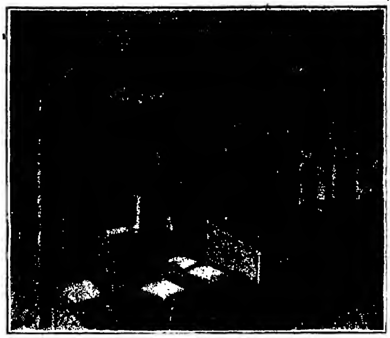
Starting with a five figure number $a\,b\,c\,d\,e$,
if $a>e$ and $b>d$, the result is 109890,
if $a>e$ and $b<d$, the result is 99099.

JOSEPH BOWDEN.

Adelphi College.

MANY of the railway lines between France and Belgium intersect the trenches, and regular trains cannot be run in those localities; but the Germans have utilized these lines by bringing in cars operated by storage batteries and operating them singly to remove the wounded from the battle front, and to bring back supplies.


The power and inspection houses at Bluestone.


Instruments and levers that control the power.

Electrification of the Elkhorn Grade

A Notable Power Equipment on the Norfolk & Western Railway

THE electrified section of the Norfolk and Western Railway, known as the Elkhorn Grade, is located on the main line in West Virginia, about 105 miles west of Roanoke, and extends from Bluefield to Vivian, a distance of about 30 miles. The section is double track throughout, except in the Elkhorn Tunnel, which is single track. There is also a large amount of third track, or passing sidings and branches into the coal workings and yard trackage.

The grades on the line are heavy, varying from 1.0 per cent at the west end to 1.5 to 2 per cent up the grade, to and through the summit tunnel, a distance of about 10 miles; thence the line descends on a 2.5 per cent grade for about a mile and then rises again at the ruling rate of about 0.25 per cent for 10.5 miles and finally up a 1.22 per cent grade for three miles into Bluefield, the easterly end of the division. Fully 60 per cent of the line is on curves, the maximum being about 12 degrees.

The electrification of this section of the railway is primarily for the purpose of collecting from the main sidings and yards in the coal fields the entire eastbound coal tonnage, and transporting it up the grades and over the summit to the classification yard at Bluefield, the division point of the railway. From Bluefield, after classification, it is shipped east to the various destination points. All coal traffic originates west of Flat Top.

There are numerous colliery sidings throughout the coal fields and the electric service includes the collection of loaded cars or trains from these sidings on the eastbound trip and the delivery of empties on the return trip. It will thus be seen that the electrified section is practically a local switching and short haul division between the coal fields and Bluefield, operated to a large extent independently of the other traffic of the main division. In addition to the heavy tonnage coal train service, however, through merchandise freight and passenger traffic over the electrified section, which is still handled by steam road engines, is also handled in part by electric engines which are used as pushers or helpers up the grades.

A condition favorable to electric traction is the fact that trains may be despatched at fairly uniform intervals throughout the day and thus desirable loading conditions on the power system are obtained and at the same time the full service is handled with a moderate number of locomotives, each making a number of round trips per day.

The purpose of the company in electrifying this section is to increase the capacity of the railway by materially reducing the time required to handle trains and to provide a more economical and efficient service over the heavy grades. To this end the heavy freight trains are handled with electric locomotives at a running speed up the grades of 14 miles per hour as compared with about 7½ miles per hour under steam operation; and a further saving in time is also effected by the elimination of the delays steam trains have heretofore occasioned by occupying the tracks while the engines take on coal and water, one at a time, at the several coal and water stations on the grade. The effect of increased speed is especially marked at the single track Elkhorn Tunnel 3,000 feet long on 1.5 per cent grade, where on account of ventilation requirements, it has been necessary under steam operation to reduce the speed up grade in the tunnel to about 6 miles per hour. This requires about seven minutes to clear the block, whereas under electric operation this movement is made in about three minutes.

The heavy coal trains, known as "tonnage trains," handled in this service weigh 3,250 tons and have formerly been handled up the grade by three steam locomotives, two of these, a road engine and helper, one at each end of the train, being used over the entire section, and the third, at the rear, serving as a pusher up the 1.5 and 2 per cent grades, this pusher being cut off at the summit. These steam engines are of the highly developed heavy Mallet type fitted with mechanical stokers and superheaters. Under electric operation a single road engine is used over the division and a second electric engine is used as a pusher up the 1.5 and 2 per cent grades. Thus it will be seen that one electric engine takes the place of two Mallets over the division or two electric engines take the place of three Mallets up the grades and handle the train at approximately double the steam speed. The speed at which the electric locomotives handle the trains on the 0.4 per cent grade between Cooper and Graham is 28 miles per hour.

The electrical installation has been laid out and power plant, locomotives and other equipment provided for handling 20 tonnage trains, or 65,000 tons, a day eastbound over the division and provision has been made for additional traffic when required. The number of these tonnage trains handled per day at present is about twelve, in addition to which pusher and helper service is provided for through freight and passenger trains.

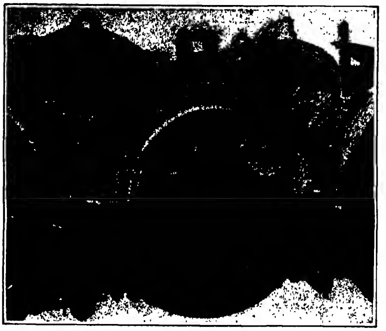
Power is generated in single phase at 25 cycles and 11,000 volts; is stepped up to 44,000 volts for distribution, and is delivered to the line at 11,000 volts, single phase, from suitably located sub-stations fitted with static transformers. The locomotives, however, are unique in that they are equipped with phase converters, which, in connection with the main step-down transformers on the locomotive, transform the single-phase power of the trolley to three-phase power for use in the three-phase induction type traction motors. Thus, while retaining all the advantages of high voltage single-phase distribution and collection, the advantages of three-phase induction motors for these heavy traction mountain grade conditions are also secured.

Another characteristic feature of the installation is the fact that as the result of the use of traction motors of the polyphase induction type it is feasible without the use of additional or complicated apparatus and devices to utilize the locomotives for electrically holding or braking the trains at constant speed while descending grades. This utilizes the energy in the moving train descending the grade to drive the motors as generators and thus return energy to the line.

This kind of electric braking or "regeneration" has been much discussed and often proposed both in this country and abroad but with the exception of the Giovi line in Italy this feature has not been utilized in any extensive commercial electric railway operation. Even on the


One of the 270-ton, 5,000 horse-power electric locomotives.

The electrical switches.



Locomotive motors and gearing.

Giovi line the train weights do not exceed 400 tons and it is evident, therefore, that this is the first instance where the use of this form of electric braking has ever been attempted for heavy freight train service such as obtains on American railroads. On the Elkhorn Grade the conditions are such that the full advantages of this form of braking can be secured as the trains are very heavy, the grades severe and speeds are relatively high. This feature of the installation has proven highly satisfactory, the heaviest trains being handled down the mountain grades with a single engine at a uniform speed of about 15 miles per hour with the utmost ease, the air brakes being held in reserve for bringing the train to a standstill when required. This results in a large reduction in the wear on the cars and locomotives generally. While the above is the principal advantage obtained from regenerative braking, there is also some saving in power due to the return of energy to the line, which is available for augmenting the power house in supplying power to other trains if there is a demand for such power at the time.

Next to the electric locomotives, the most interesting feature of the electrification is probably the catenary line construction. In designing this feature of the installation, the engineers had uppermost in mind the two important requirements of reliability of service and low cost of maintenance. An effort has been made to secure the maximum degree of flexibility and freedom from hard spots at the contact wire so as to avoid rapid deterioration and frequent breakages and failures.

In working out the design on these lines the catenary system has taken the form of single catenary with an auxiliary messenger wire above the trolley, one main hanger being provided for every two intermediate connections between auxiliary and trolley on tangents. On curves the angularity of the hangers provided the necessary flexibility, the auxiliary messenger and trolley wire being both connected to the hanger at the same point.

Great care has been taken also to provide ample clearance between every live part and adjacent grounded structures and as a rule this clearance is maintained at not less than 18 inches so as to avoid the danger of birds or foreign materials causing a short circuit. The same principle applies in the tunnels, the insulators are, however, placed off to the side and out of the direct blast from locomotive stacks and here two 44,000 volt transmission line insulators in series are used in all cases between live points and ground.

The line supports are light bridges made of tubular poles and Bethlehem "H" section crossbeams, and the structures are guyed on the outside of curves to resist the curve pull by means of two heavy guy rods secured in concrete anchorages. At signal bridges the signals and catenary systems are supported on structural bridges which consist of latticed posts carrying shallow plate girders which form as little obstruction to the view of signals as possible and are easily painted and maintained. The same type of bridge is used on curves where it is impossible to provide guys at the outside of the curve.

In addition to the direct advantages and savings resulting from the electric train service the railway has taken advantage of the presence of an adequate power supply at net cost of generation for the operation of various auxiliary plants. Thus a large steam pumping station at Bluestone for the water supply for steam locomotives has been shut down and the pumping is done at the electric power station located nearby, and the fans for ventilating the Elkhorn Tunnel will now be driven by electric motors.

The layout and design of the entire installation was worked out in all details by Gibbs and Hill, engineers for the company. All construction, excepting the power house and inspection buildings and some of the power station equipment, was carried out by a specially organized railroad force under the supervision of the engineers.

The power station is of the usual type using steam boilers and steam turbines as the prime movers. It is located at Bluestone on the Bluestone river about 11 miles west of Bluefield mainly for the reason that this is almost the only available source of water for boiler feed and condensing purposes in the district and the railway company had already constructed a dam and reservoir here for the water supply for its steam locomotives.

The main structure is about 135 feet by 158 feet with a 52 foot by 33 feet extension at the northeast corner, and contains, besides extensive power and auxiliary plants, the usual switching outfits, and accommodations for the operating staff, the extension containing the transformers.

The boiler plant comprises ten Stirling type water tube boilers, designed for a working pressure of 225 pounds gage and equipped with superheaters capable of superheating the steam 150 deg. Fahr. at normal rating. Each boiler is fitted with an underfeed stoker.

The initial power equipment consists of three horizontal turbines of the Westinghouse-Parsons impulse reaction double flow type rated at 10,000 kilowatts with steam at 190 pounds, superheated 150 deg. Fahr. and 28½ inch vacuum when running at 1,500 revolutions per minute, and governed by an oil relay mechanism for operating the steam valves.

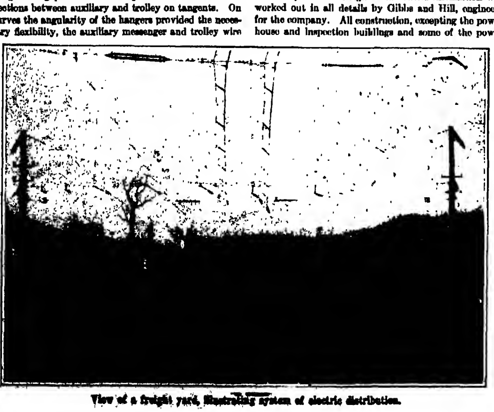
The main turbo-generators are of the Westinghouse type having a rating of 10,000 kilowatts at 80 per cent power factor, 11,000 volts, 25 cycles, single phase. At this rating, the generators are specified to operate for 24 hours with a rise in temperature not exceeding 60 deg. Cent. above the temperature of the cooling air.

Excess regenerated power returned to the power house at no load passes to the 11,000 volt bus and through the various transformers back to the generators if the generators are running under very light load or no load. If no other load were provided, the regenerated power would reverse the generators and operate them as motors. To prevent this a loading device consisting of electrodes immersed in the intake canal and controlled by suitable switches is provided.

The operation of the switches is made automatic by means of a group of relays and magnetic switches, current transformers, etc, so connected as to give the following results:

When the amount of excess regenerated power reaches say 300 K.V.A. the closing relays throw in one water rheostat on the 11,000 volt bus. As soon as the regenerated power exceeds the capacity of one water rheostat by 300 K.V.A. another closing relay throws the second water rheostat in on the 11,000 volt bus. The difference between the amount of excess regenerated power and the capacity of the water rheostats in service is made up by the generators.

When the excess regenerated power has become reduced to zero with one rheostat in service all of the rheostat load being supplied by the generators one of the tripping relays trips the circuit breakers which cuts the rheostat off the 11,000 volt bus. With two rheostats in service, when the excess regenerated power drops to 2,000 K.V.A. one of the relays opens the breaker which was closed first and cuts one rheostat out of service. The other rheostat remains in until the excess regenerated power drops to zero when it, too, is cut out of service.



View of a freight yard, illustrating system of electric distribution.

Each rheostat consists of a steel cone carrying a load from the circuit breakers, and a fixed ingot iron plate located at the bottom of the intake canal, and grounded to a copper plate bedded in the earth outside of the canal. The power dissipating capacity is adjusted by varying the distance between the cone and the iron plate. The cone is raised or lowered in the water of the canal by means of a hand-operated winch and cable carried on a steel bracket across the canal.

The traffic on the electrified section is handled by twelve 270-ton Baldwin-Westinghouse locomotives, each consisting of two 135-ton units or halves.

It is necessary in handling heavy trains on mountain grades to have a part of the motive power at the rear of the train in order to avoid excessive strains on the draught rigging of the cars. In this case the power is divided equally between the two ends of the train and the trains are of such great length in this mountainous country that there is difficulty of signaling from one locomotive to the other and thus the locomotives are subject to treatment which would be considered impossible in ordinary service. For instance, it is not unusual for the rear locomotive on receiving a starting signal to stand still for a minute or more exerting full tractive effort in an effort to start the train before the head locomotive has got into full action. Also in stopping a train the head engine shuts off power and the brakes are applied while the rear engine keeps pushing the train until it comes to a standstill. This would require some very careful handling with the ordinary locomotive, but the electric is designed to meet just these severe requirements of the service and that without involving special manipulation. In meeting these conditions the rugged construction of the three-phase induction motor being free from commutators, the liquid rheostats are of the greatest importance. The liquid rheostat not only gives the smoothest possible gradations of tractive effort, but the latent heat of steam makes it possible without difficulty to dissipate the large amount of heat generated in the rheostat in meeting this severe requirement.

Each unit has two main trucks connected by a Mallet type hinge, and each main truck has two driving axles included in a rigid wheel base with a radial two-wheel leading truck. The bumping and pulling stresses are transmitted through the main truck frames and through twin draught rigging mounted on the main trucks at each end of the unit. The cab is of the box type and is supported on the main truck entirely by spring cushioned friction plates, there being no weight on the center pins, which serve only to maintain the cab in its proper position on the trucks. An engineer's compartment is provided at one end of each unit, the two units being so coupled as to provide for operation from either end of the locomotive. Each locomotive is equipped with eight traction motors of the three-phase induction type, with wound secondaries for four pole and eight pole operation.

There are two running speeds, 14 and 28 miles per hour. In starting, resistance is inserted in the secondary circuit of the motor by means of a liquid rheostat. For the 14 miles per hour speed all motors are connected in parallel, having the eight pole motor combination; and for the 28 mile per hour speed they are also connected in parallel but with the four pole motor combination. The locomotives are equipped with unit switch type of control and arranged for the simultaneous operation of the two units from the control end of either.

The control equipment is built for handling alternating current, which is collected from the 11,000 volt line by the pantagraph trolleys. This current is fed to the main transformers through an oil type circuit breaker. A phase converter is connected to the low tension side of the transformer and operates constantly when the locomotive is in service. To its extended shaft are coupled a blower for cooling the motors, transformers and other parts, and, through a clutch the air compressor.

The two trolleys mounted on the roof of each unit, are of the well known pantagraph type, but are unique in that they have been arranged so that if necessary they may be fitted with end horns which will automatically fold in when the pantagraph is lowered by the tunnel trolley wire. In this way the unusually wide sliding surface will accommodate itself to the restricted tunnel clearances. The trolley is raised and held in contact with the overhead wire by springs and is lowered by compressed air. When locked down the trolley can only be released by air pressure. When air is not available in the reservoirs one trolley on each unit is arranged so that it may be unlocked and raised by a small hand pump.

On each unit there are four liquid rheostats, one for each motor. The rheostats are operated in pairs, and provide the motor circuit resistance required in order that the speed of the motors may be slow at starting and may be gradually increased as the resistance is cut out of circuit.

The principal dimensions and weight of each complete locomotive is as follows:

Length overall	105 feet	8 inches
Driving wheel base, total	88 feet	10 inches
Rigid wheel base	11 feet	0 inches
Truck wheel base	16 feet	6 inches
Height, rail to pantagraph (locked)	16 feet	0 inches
Height, rail to top of cab (maximum)	14 feet	9 inches
Width overall (maximum)	11 feet	6¼ inches
Diameter of driving wheels		62 inches
Diameter of pony wheels		30 inches
Weight on drivers	220 tons	
Total weight of locomotive	270 tons	

The following table shows the performance of these locomotives under varying conditions of load:

	Train on 1.5 and 2 per cent grades	Train on 1 per cent grades	Train on 1.4 per cent grades
Weight of train—tons	3,250	3,250	3,250
Locomotives per train	2	1	1
Approximate speed, miles per hour	14	14	28
Drawbar pull per locomotive, pounds			
Uniform acceleration	91,800	114,000	79,400
At speed on 2 per cent grade	75,400		
At speed on 1 per cent grade		85,800	
At speed on 0 4 per cent grade			4,600
Maximum guaranteed accelerating tractive effort per locomotive	133,000	133,000	90,000
Approximate maximum guaranteed horse-power developed by motors	5,000	5,000	6,700

On tests and in service the locomotives have developed a drawbar pull considerably in excess of the guaranteed maximum. The highest record with the dynamometer car being 180,000 pounds. This corresponds to an adhesion of about 40 per cent.

Problems of Geographic Influence*

Geography offers help and co-operation to all sciences that deal with man, anthropology, ethnology, history, sociology, economics, psychology and comparative religion, and from each of these geography will gather data for its own perfecting.

The historian, for example, needs from the geographer a more full knowledge of environmental working, and the geographer receives in turn much from the historian. The old geography knew little of the causal and historical, and some of the old history might just as well have been staged on a flat platform projected into the interplanetary ether.

If history is to strike deep roots into the earth, if it is to set forth with full discernment, the molding, moods, motives, and movements of men, the historian will need help from the geographer; and the historian, skeptical of generalisations that are too easy and scorning overstatement, will respond with open hand to every real offering of the geographer.

When geography was poorer than to-day, Parkman wrote the human story out of its environment. James Bryce has always and without stint placed geography in the running with historical movements. And if the generalizations of Bryce, like those of Ratzel, are sometimes tinged with vagueness, let us blame, not the historian of broad outlook, but the geographer whose work is yet in arrears. Other examples are not wanting. Winsor, in dedicating his Mississippi Basin to Mr. Markham, then president of the Royal Geographical Society, writes of environment:

"I would not say that there are not other compelling influences but no other control is so steady."[1]

Mr. Edward John Payne has written a "History of the New World called America." Being no historian, I do not know the craft's estimate of that work, but I am astounded at the author's deep and broad knowledge of environment in the lands whose story he tells. The surface, the climate, the possibilities of cereal production and of the domestication of certain animals appear in such wise in relation to early American civilization, to the arts and habits of the people, as to stir the geographer to admiration. Whether all of Payne's conclusions stand fire or not, he gives an example of effort aimed at precision. This is a call to every geographer. The geographic atmosphere in Prof. Turner's story of our north central west is known to us, and Prof. J. L. Myres, reaching at once broadly into the fields of classic lore, anthropology and geography, is, in his person and work, living testimony to the importance of our anthropogeographic task, and to the hopefulness that lies in our attempting it.

Some historical writers are influenced little, if at all, by the study of the earth and lower life as elements of human environment. Even volumes professing to deal with the geographic foundation of history sometimes fall of their goal, and one preface affirms that—"the general physiography of North America is familiar enough to readers."

This, I am sure, is quite too rosy a view of the geographic situation. But I cite the limitations of some histories in no mood of criticism. Let every man build the wall over against his own house. What of assured fact or proven principle we put before the historian he has neither the wilt nor the power to escape. Our light is in no danger of being put under a bushel. But we have good need to see that it is lighted.

If we turn to sociology we meet the insistence on the importance of environment. Let us take Giddings's definition, that "sociology is an attempt to account for the origin, growth, structure, and activities of society by the operation of physical, vital and psychical causes, working together in the processes of evolution."

Or we may cite the utterance of Small, that "this force is incessant, that it is powerful, that it is a factor which may never be ignored."[1] Yet Dr. Small in an extended chapter on environment mentions geography but once, and then not as a science which might contribute to sociology. Prof. Ridgeway[2] thinks that failure fully to recognise man as controlled by the laws of the animal kingdom leads to maladministration of alien races and blunders in social legislation. He says, further, "As physical characteristics are in the main the result of environment, social institutions and religious ideas are no less the product of environment," and again, any attempt to eradicate political and legal institutions of an equatorial race "will be but vain, for these institutions are as much part of the land as are its climate, its soil, its fauna, and its flora." Ripley, in reviewing the second volume of Ratzel's anthropogeography, criticises the author for neglecting acclimation, considering its importance in social theory, and in view of the fact that theories of race dispersion turn upon our judgment in this matter. Perhaps the real state of the case is seen in the appearance not long ago of a serious and careful volume on the development of western civilization, which nevertheless exhibits an utter dearth of geographic data and also principles.

We are safe then in saying that most authorities in these sciences of man recognise environment as fundamental, but the greater part, in a sort of absolution of conscience, name the subject and take leave of it.

We need not, therefore, expect the historians or the sociologists to develop in any full way the principles of environmental action. They admit the need of these principles, but have not the time, perhaps not the will, to develop them. It remains for us to put content into the word environment, so that it cannot be overlooked or slighted, and so that its meaning may become available in plain terms to all.

In his "Racial Geography of Europe" Ripley asserts that: "To-day geography stands ready to serve as an introduction as well as a corrective to the scientific study of human society."

This was written about twenty years ago, and yet it is to-day not so valid or truthful a statement as we could desire it to be. Our convictions are in the right place and much has been done, but we still suffer from a dearth of limited, local, special and proven data, and a surplus of generalisations announced with the enthusiasm of fresh discovery, or rediscovery, unsupported by adequate evidence. We are subject to Marett's criticism of certain generalizations of Ratzel and Le Play—"too pretty to be true."[3] We are awaking to the importance of our field, and this is well, but it is equally important to make haste slowly and to give human geography a content satisfying to ourselves and convincing to our fellow workers in adjoining fields.

The pursuit of our theme is as difficult as it is important. Prof. Cramb in a recent book[4] comments on the causal idea so common in our modern thought about history. His word is equally good for us. He says:

"In man's history nothing is more difficult than to attain to something like a just conception of a true cause."

Universality and necessity are the criteria which he proposes. A stiff application of these principles would be a tonic for some geographical theorising.

* Abstracts from the address of Prof. Albert P. Brigham, president of the Association of American Geographers, at the eleventh annual meeting at Chicago.

[1] "Mississippi Basin," Justin Winsor, following title page.

[1] "General Sociology," A. W. Small, 415.

[2] William Ridgeway, "The Application of Zoological Laws to Man," Brit. Assoc. Ad. Sci., Dublin, 1908, 832-847.

[3] R. R. Marett, M.A., "Anthropology," [illegible]

[4] J. A. Cramb, "Germany and England," [illegible]

One of the principal exhibits at the Panama-Pacific Exposition is one of the Pennsylvania Railroad electric locomotives mounted on a 60-foot turntable. This locomotive is said to be the largest in the world in passenger service. It consists of two units and weighs [illegible] tons, and is the first side-rod gearless locomotive ever placed in service. It has two motors having a total capacity of 4,000 horse-power.

The Time System of the United States

Why It Exists and Some of Its Vagaries and Defects

By Charles T. Higginbotham

Our present method of calculating and indicating time is a legacy from the ancient Romans. Having become accustomed to it through long years of use we fail to notice its shortcomings, inconsistencies, and absurdities. It is only when our attention is particularly directed to some glaring inconsistency or some unbearable hardship that we wake up to the situation and take measures to relieve ourselves of some burden that it imposes upon us.

Such a condition forced itself upon the attention of the public in 1883. Previous to that year each city and town reckoned its time from its meridian. This is to say, from the meridian passing through that particular place. It was impracticable for railways to arrange their time tables to conform strictly with this condition. Some attempts made to do so created considerable confusion. It necessitated the engineer and other train hands setting their watches at nearly every important station. This proved a very costly practice to the railroad companies and was the direct cause of some disasters. There were upward of fifty different kinds of railway time in the United States, and it was a usual thing for jewelry stores to provide their regulators with two minute hands, one for local time and one for railway time. This caused so much inconvenience to the public and became such a source of trouble to railway managers that, in order to relieve the situation, an agreement was entered into to adopt four meridians from which time for the United States should be taken.

The meridians adopted for this purpose were the 75th, from which Eastern time is taken. The 90th, for Central time, the 105th for mountain time, and the 120th for Pacific time. These meridians are 15 degrees apart, making a difference in time of exactly one hour between each. All the railways throughout the United States now arrange their time tables approximately in conformity with these meridians.

On November 18th, 1883, this new system went into effect and there was a general re-setting of clocks and watches all over the country. Every city and town now uses for its local time one of these meridians, the one used being identical with that used by the railways passing through, or terminating at that place.

To fully comprehend the use of these meridians it must be borne in mind that longitude is universally reckoned from Greenwich. Every sea captain all over the world, regardless of from what port he sails or to what port he is bound, sets his chronometer by Greenwich time. It must also be borne in mind that the time occupied by the earth in making a revolution is 24 hours. Dividing 360 degrees by 24 hours gives 15 degrees; consequently 15 degrees has a time value of one hour. This is to say, the apparent motion of the sun from east to west is at the rate of 15 degrees per hour.

The meridians, it will be understood, run north and south. The 60th, from which Atlantic time is taken, passes through the eastern parts of the province of Quebec and New Brunswick, Canada. This meridian is used on some of the Canadian railways, but is not used in the United States. The 75th meridian, from which Eastern time is reckoned, passes through Herkimer, New York, Western New Jersey and Eastern Pennsylvania, about midway between Trenton and Philadelphia. The 90th meridian, from which Central time is reckoned, passes through the extreme eastern edge of Minnesota, the western part of Michigan, the center of Wisconsin; through Illinois, 17 miles west of its capital—Springfield—and 12 miles east of St. Louis, through the extreme eastern parts of Missouri and Arkansas, the western part of Tennessee, 8 miles east of Memphis, through Mississippi, 2 miles west of Jackson, and through the eastern side of Louisiana, 5 miles east of New Orleans. The 105th meridian, from which mountain time is reckoned, passes through eastern Montana, 40 miles east of Miles City; through eastern Wyoming, 10 miles west of Cheyenne; through Denver, and 10 miles west of Colorado Springs; through New Mexico, 35 miles east of Santa Fe; and through the extreme west of Texas, 35 miles east of El Paso. The 120th meridian, from which Pacific time is reckoned, passes centrally through the States of Washington and Oregon, forms the dividing line between Nevada and California, to a point 12 miles west of Carson City, thence through the center of California.

The [illegible] meridian furnishes time for a larger area [illegible] other. As a matter of fact it supplies time [illegible] of the inhabitants of the United States. It requires three meridians to supply the remaining 45 per cent. There are, however, confusing irregularities caused by the locations selected by the railway companies for changing their time schedules. This is unavoidable. Railways cannot be expected to change time exactly midway between meridians. They usually select the termination of divisions for that purpose. As a result the Eastern and Western boundaries of the area using Central time form zigzag lines. This condition is productive of strange situations. Traveling from Greensburg, Kansas to Beverly, Nebraska—a distance of about 200 miles due north—it becomes necessary for the traveler, if he would have his watch agree with the time used in the different towns through which he passes, to set it four times during his journey. This is owing to his crossing the zigzag boundary lines as laid out by the railroads.

Whenever a change of time is made by a railway there must of necessity be two kinds of time at that place. At Pittsburgh they are Eastern and Central. Trains going east use the former, and those going west the latter. Buffalo has the same condition in an exaggerated form, for the reason that all trains going east use eastern time, while trains going west use both eastern and central. The Grand Trunk, the Michigan Central and the Wabash use Eastern time, while all roads south of Lake Erie use Central. Trains arrive and depart from El Paso, Texas, on four different kinds of railway time: Central, Mountain, Pacific and Mexican. It is impossible to estimate the loss to the traveling public from mistakes caused by this confusing state of affairs, but in stating that the monetary loss to the public from time spent in efforts to decipher and unravel the complications in our railway time tables, brought about by our present confusion system is $5,000,000, would not seem to be very far from being correct. That this is not an exaggerated estimate may be seen when we consider that American railways carry two and a half million passengers daily. If the average loss of time in deciphering and studying time tables is one half cent per passenger the yearly aggregate would amount to $4,562,500. In addition to this our complicated system involves increased labor and expense to the railway companies in making out their time tables. Here then we have $5,000,000 a year absolutely wasted. Enough to build a battleship, and this does not take into account the amount lost by mistakes arising from the same cause.

Another fruitful source of confusion and mistakes is the method of dividing the day and night into two periods of 12 hours, numbered, 1 to 12, necessitating the use of those awkward and inconvenient affixes A. M. and P. M.

The Egyptians were the first to divide the day and night into 24 equal parts. They numbered the hours 1 to 24. The Romans began their day at sunrise, numbering the hours to sunset 1 to 12, and numbering them from sunset to sunrise also 1 to 12. Our A. M. and P. M. is a part of the burdensome legacy inherited from them. The hours constituting their day and night were of unequal and constantly varying lengths. In course of time they made a change to our present system, and had they adopted the Egyptian method they would have conferred an inestimable benefit upon mankind.

The remedy for the evils we have described lies: First, in numbering the hours as the Egyptians did. Beginning, as we now do at midnight we would number the hours up to noon 1 to 12; the hour we now designate as 1 P. M. would be 13, and so on to 24. Second, we should adopt one meridian for the entire United States, which could be done without any serious disturbance of affairs. The change which was made in 1883 was hardly noticed and proved a great benefit without working hardship on anyone. The advantage secured by that change was insignificant as compared to the advantage to be secured by the use of one meridian and the 24-hour system.

Canada has already adopted the 24-hour system on all her railroads west of Port Arthur, and China has adopted one meridian for the entire empire, which embraces 60 degrees, the same amount as the United States. Shall we allow ourselves to be left behind by other nations?

Let us suppose that the 90th degree—central meridian—should be adopted as the one from which United States time should be reckoned; what then would be the effect on business? The hour of 8 A. M. is now pretty generally adopted for the commencement of business. If we should take our time from the central meridian it would be 9 in New York, 8 in Chicago, 7 in Denver and 6 in San Francisco; but what matters it where the hands of the clock point so long as business commences the same amount of time after sunrise? Clocks and watches should be our servants, not we theirs.

On April 15th the sun rises at Philadelphia at 5 o'clock as we now reckon time. This is to say, the Philadelphians commence business 3 hours after sunrise. The only difference that the change would produce is that the hands of their clock would point at 9 instead of 8.

We would soon become accustomed to the proposed change and the great benefit and saving resulting therefrom would repay us many times over for any slight inconvenience that might at first be felt. With this system in force there would be *no* setting and resetting of traveler's or railroad employee's watches. One might travel from coast to coast without disturbing his watch. The reading of railway time tables would be so simplified that there would be no excuse for making mistakes. The absurdities that now exist in the matter of time would be eliminated.

By our present system of reckoning time it would have been possible for an event to have occurred in New York on January 1st, 1911, at 1 A. M., and *for* that event to have been known in San Francisco at 10 P. M., December 31st, 1910. It is now possible to leave El Paso for the West one hour and fifty minutes before you arrive from the East—according to railway time tables. The writer recently saw the apparent anomaly of two trains standing side by side in the station at Buffalo, both headed for the West, yet the engineers' and conductors' watches on one train were just *one* hour ahead of the other. This sort of incongruity would be impossible with the proposed new system.

Half a century ago there was not a watch in existence capable of meeting the requirements of American railway time service to-day. Railway time inspection has set the limit of variation from true time, for its employees' watches, at 30 seconds a week. This means that the balance wheel shall not vary in its motion to the extent of one vibration out of every 20,000. Taking into consideration the various causes of disturbance to which a railway engineer's watch is subjected, the jolts and jars, the changes of temperature and the magnetic influence incidental to the proximity of large masses of iron and steel, this performance is truly remarkable. That it is possible to secure such accuracy in such a tiny piece of mechanism subjected to these adverse influences is little short of marvelous, and justifies the claim that the watch of to-day is the most wonderful piece of mechanism that the ingenuity of man has ever produced.

The requirement for accuracy in railway watches in particular, and for others as well, is becoming more exacting every day. Horologists are at their wits' end to meet them. The time is surely coming when a purely mechanical device will no longer suffice to produce sufficient accuracy. What then? Some other force of nature must be enlisted. What will it be? What else but that mysterious force, electricity? That wonderful power which is being harnessed to lighten man's burdens and minister to his wants and pleasures. Yes: Wireless Electricity is destined to solve the problem.

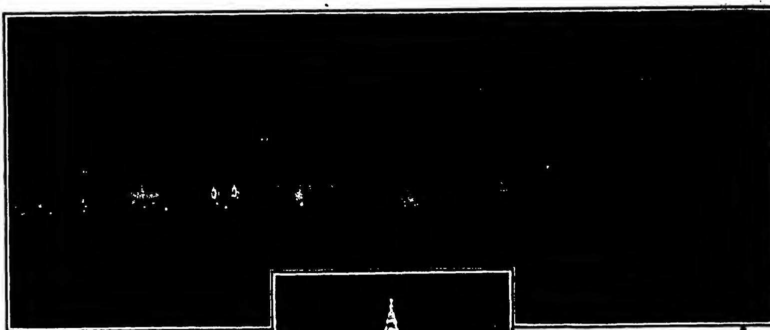
The time is now sent out from the observatory at Washington from an astronomical clock, so protected against all disturbing influences that it runs with infinitesimal variation, and is corrected by nightly stellar observations. Centrally located clocks controlled from this master clock at Washington will be used to send out aerial electric waves. These clocks will control a radius of, perhaps, one hundred miles. The watch and the clock of the future, like their precursors, the sun-dial and the clepsydra, will be relegated to the shelves of our museums, their places taken by electric receivers contrived to indicate time received from these central clocks. The railway engineer will no longer depend upon a mechanical contrivance which is always liable to error in its indications of time. He will press a button and read the time to the second, in exact conformity with the accurate astronomical clock at Washington. The little instrument which he carries will be no larger than a watch.

It may be asked: Will not the new instrument be liable to get out of order, and give incorrect time? No! The new instrument will never lie. It may get out of order, but will never lead to a mistake. It will either indicate correct time or no time at all.

Illumination of the Panama-Pacific Exposition*

Wonderful Effects Produced by Modern Apparatus and the Engineer's Art

By W. D'A. Ryan, Chief of Illumination



Palaces of Transportation and Mines softly illuminated by reflected light.

The Tower of Jewels.

The illumination of the Panama-Pacific International Exposition is a development in the art of illumination made possible by the science of lighting which grew up under the name of illuminating engineering and had its inception at the Thomson-Houston plant of the General Electric Company at Lynn, Mass., nearly 20 years ago.

While in charge of the expert course, the writer came closely in contact with the development of the Thomson '93 arc lamps which in various ornamental forms were designed for alternating and direct current series and multiple circuits. The inclosed arcs soon made their appearance and these lamps added to the existing lighting sources suggested the necessity of a careful scientific study in the selection, location, reflectoring and globing of the various units to obtain maximum results at minimum cost for industrial use, store and street lighting, and other purposes.

That illuminating engineering was to form such an important specialized branch of electrical engineering was not at first recognized, but after considerable progress had been made in this particular field the title of Illuminating Engineer became generally acknowledged. From that time on the development has been very rapid. New photometers, luximeters, and luminometers were built for laboratory and field work. Lumichronoscopes were designed for studying effects of different lights on various colored materials, diffusers made their appearance, scientific glassware and reflectors swept over the land, extensive laboratory and field tests were made and the development became general.

In lighting propositions involving special effects or treatment, it has become the practice to employ an illuminating engineer in addition to the electrical engineer. It was therefore natural that when the Panama-Pacific International Exposition decided that its illumination should possess features of novelty to correspond with its general policy it recognized the necessity of establishing a department of illuminating engineering in addition to the electrical and mechanical department, which came under the direction of Mr. G. L. Bayley.

Mr. Bayley's application to the General Electric Company resulted in the writer's appearing before Mr. H. D. H. Connick, director of works, and the architectural commission in August, 1912, to consider the preparation of lighting plans along original lines. Three months later a scheme and scope was presented to the architectural commission and the writer was officially appointed "Chief of Illumination" in charge of the illuminating and spectacular effects, also the design of lighting standards and fixtures and the selection of the glass for the buildings and various lighting units.

As a result, for the first time in history the lighting of an International Exposition was completely designed and charted before the buildings were erected.

A detailed description of the lighting in a limited space is, of course, impossible, and it is the purpose of this article to convey a general idea of the effects rather than the means employed to produce them.

*The General Electric Review.

The illumination of the Exposition marks an epoch in the science of lighting and the art of illumination. Like many other features of the Exposition, the illumination is highly educational in character and emphasizes more than anything that has gone before the result of concentrated study in the best uses and application of artificial light.

Previous exposition buildings have, in the main, been used as background on which to display lamps. The art of outlining, notably the effects obtained at the Pan-American Exposition at Buffalo, could probably not be surpassed. This method of illumination has, however, been extended to amusement parks throughout the world and is now commonplace. Its particular disadvantage is that it suppresses the architecture which becomes secondary and it is practically impossible to obtain a variety of effects, so that the Exposition from every point of view presents more or less similarity. Furthermore, the glare from so many exposed sources, particularly when assembled on light colored buildings, causes eye strain. Prior to the opening night of the Exposition, there were many who maintained that the public would not be attracted except by the glare of exposed sources and great brilliancy, which was analogous to saying that the masses could be attracted only by one form of lighting. The results obtained, however, clearly disproved this theory.

The lighting effects are radical, daring and in every sense new, the fundamental features of which consist primarily of masked lighting diffused upon softly illuminated facades emphasized by strongly illuminated towers and minarets in beautiful color tones.

The direct source is completely screened in the main vistas and the "behind the scenes" effects are minimized to a few locations and are nowhere offensive.

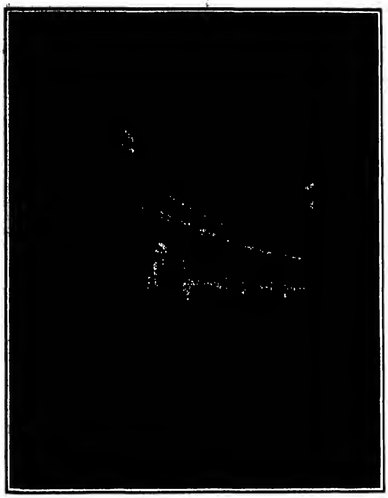
Furnishing wonderful contrast to the soft illumination of the palaces, with their high lights and shadows, we have the Zone, or amusement section with all the glare of the bizarre, giving the visitor an opportunity to contrast the light of the present with the illumination of the future. As we pass from the Zone with its blaze of lights, we enter a pleasing field of enticement or carnival spirit. We are first impressed with the beautiful colors of the heraldic shields on which is written the early history of the Pacific Ocean and California. Behind these banners are luminous arc lamps in clusters of two, three, five, seven and nine, ranging in height from 25 to 55 feet. We look from the semi-shadow upon beautiful vistas, and the Guerin colors which fascinate in the daytime are even more entrancing by night. The lawns and shrubbery surrounding the buildings and the trees with their wonderful shadows appear in magnificent relief against the soft background of the palaces and the "Tower of Jewels" with its 102,000 "Nova-gems," or so-called exposition jewels, standing mysteriously against the starry blue-black canopy of the night, surpassing the dreams of Aladdin.

As we enter the "Court of Abundance" from the east, with its masked shell standards strongly illuminating the cornice lines and gradually fading to twilight in the foreground, we are impressed with the feeling of mystery analogous to the prime conception of the architect's wonderful creation. Soft radiant energy is everywhere; lights and shadows abound, fire spits from the mouths of serpents into the flaming gas cauldrons and sends its flickering rays over the composite Spanish-Gothic-Oriental grandeur. Mysterious vapors rise from steam electric cauldrons and also from the beautiful central fountain group symbolizing the Earth in formation. The cloister lanterns and the snow-crystal standards give a warm amber glow to the whole court and the organ tower is carried in the same tone by colored searchlight rays.

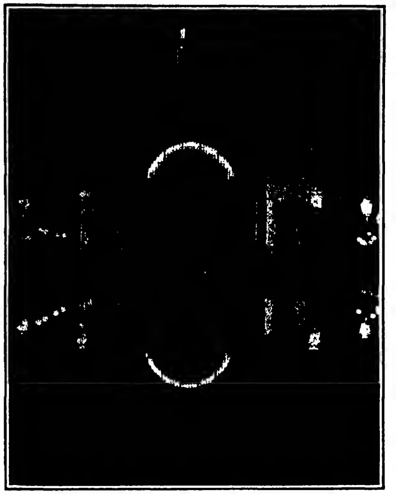
Passing through the "Venetian Court," we enter the "Court of the Universe," where the illumination reaches a climax in dignity, thoroughly in keeping with the grandeur of the court, where an area of nearly half a million square feet is illuminated by two fountains, rising 95 feet above the level of the sunken gardens, one symbolizing the rising sun and the other the setting sun.

The shaft and ball surmounting each fountain is glazed in heavy opal glass which is coated on the outside in imitation of travertine stone so that by day they do not in any sense suggest the idea of being light sources. Mazda lamps installed in these two columns give a combined initial mean spherical candle-power of approximately 500,000 and yet the intrinsic brilliancy is so low that the fountains are free from disagreeable glare and the great colonnades are bathed in a soft radiance. For relief lighting three Mazda lamps are placed in specially designed cup reflectors located in the central flute to the rear of each column. This brings out the Pompeian red walls and the cerulean blue ceilings with their golden stars and at the same time the sources are so thoroughly concealed that their location cannot be detected from any point in the court.

The perimeter of the "Sunken Garden" is marked by balustrade standards of unique design consisting of Atlantes supporting urns in which are placed Mazda lamps of relatively low candle-power. The function of these lights is purely decorative.



Illuminated outer vestibule of Fine Arts Building.



Festival Building illuminated by diffused light.

The great arches are carried by concealed lamps, red on one side and pale yellow on the other, thereby preserving the curvature and the relief of the surface decorations. The balustrade of this court, 70 feet above the sunken garden, is surmounted by 90 seraphic figures with jeweled heads. These are cross lighted by 180 Mazda searchlights, the demarcation of the beams being blended out by the light from the fountains of the rising and the setting sun.

Passing through the Venetian Court to the west, we enter the "Court of the Four Seasons," classically grand. We are now in a field of illumination in perfect harmony with the surroundings, suggesting peace and quiet. The high current luminous arcs mounted in pairs on 25-foot standards masked by Greek banners are wonderfully pleasing in this setting. The white light on the columns causes them to stand out in semi-silhouette against the warmly illuminated niches with their cascades of falling water, and the placid central pool reflects in marvelous beauty scenes of enchantment.

Having reviewed in order illuminations mysterious, grand and peaceful, we emerge from the West Court upon lighting classical and sublime, the magnificent Palace of Fine Arts bathed in triple moonlight and casting reflections in the lagoon impossible to describe. The effect is produced by searchlights on the roofs of the Palaces of Food Products and Education supplemented by concealed lighting in the rear cornice soffits of the colonnade.

You have only passed through the central, east and west axis of the Exposition. There are many more marvels to be seen. If you wish to study the art of illumination you could visit the Exposition every evening throughout the year and still find detail studies of interest. For instance, did you ever see artificial illumination in competition with daylight? On certain occasions the projectors flood-light the towers before the sun goes down. If you are fortunate enough to be present, take up a position in the northwest section of the "Court of the Universe" and watch the marvelous effect of the "Tower of Jewels" as the daylight vanishes and the artificial illumination rises above the deepening shadows of the night. The prismatic colors of the jewels intensify and the tower itself becomes a vision of beauty never to be forgotten.

The South Garden may very properly be called the fairy-land of the Exposition at night. When the lights are first turned on, the five great towers are bathed in ruby tones and they appear with the iridescence of red hot metal. This gradually fades to delicate rose as the flood-light from the arc projectors converts the exterior of the towers into soft Italian marble. The combination of the projected arc light (white) and the concealed Mazda light (ruby) produces shadows of a wonderful quality. Each flag along the parapet walls has its individual projector which converts it into a veritable sheet of flame.

As a primary line of color the heraldic shields and cartouche lamp standards produce a wonderful effect against the travertine walls bathed in soft radiance from the luminous arcs which also bring out the color of the flowers and lawns and create pleasing shadows in the palms and other tropical foliage. This is supported by a secondary effect in the decorative Mazda standards along the "Avenue of Palms" and throughout the garden. A finishing touch is added by the effect of life within created by the warm orange light emanating from all the Exposition windows supported by red light in the towers, minarets and pylon lanterns.

To the west we have the enormous glass dome of the Palace of Horticulture converted into an astronomical sphere with its revolving spots, rings and comets appearing and disappearing above and below the horizon and changing colors as they swing through their orbits. The action is not mechanical, but astronomical.

To the east, we have the "Festival Hall" flood-lighted by luminous arcs and accentuated by orange and rose lights from the corner pavilions, windows, and lantern surmounting the dome, all reflected in the adjacent lagoon and possessing a distinctive charm which will long remain in the memory.

Purely spectacular effects have been confined to the scintillator at the entrance of the yacht harbor. This consists of 48 36-inch projectors having a combined projected candle-power of over 2,600,000,000. This battery is manned by a detachment of United States Marines.

A modern express locomotive with 81-inch drivers is used to furnish steam for the various fireless fireworks effects known as "Fairy Feathers," Sun-burst," "Chromatic Wheels," "Plumes of Paradise," "Devil's Fan," etc. The locomotive is arranged so that the wheels can be driven at a speed of 50 or 60 miles per hour under brake, thereby producing great volumes of steam and smoke, which, when illuminated with various colors, produces a wonderful spectacle.

The aurora borealis created by the searchlights reaches from the Golden Gate to Sausalito and extends for miles in every direction. The production of "Scotch Plaids" in the sky and the "Birth of Color," the weird "Ghost Dance," "Fighting Serpents," the "Spook's Parade" and many other effects are fascinating.

Additional features consist of ground mines, salvos of shells producing "Flags of All Nations," grotesque figures and artificial clouds for the purpose of creating midnight sunsets.

Over 300 scintillating effects have been worked out and this feature of the illumination is subject to wide variation. Atmospheric conditions have a great influence upon the general lighting effects; for instance, on still nights the reflections in the lagoons reach a climax particularly the Palace of Fine Arts as viewed from Administration Avenue; the facades of the Education and Food Products Palaces as seen in the waters through the colonnade of the Palace of Fine Arts; the Palaces of Horticulture and Festival Hall from their respective lagoons in the South Garden; the colonnades and the Nova-gems on the heads of the seraphic figures, and the "Tower of Jewels" as reflected in the water mirror located in the North Arm of the "Court of the Universe."

On windy nights the flags and jewels are at their best. On foggy nights wonderful beam effects are produced over the Exposition impossible at other times. When the wind is blowing over the land the scintillator display is different from nights when the wind is blowing across the Bay. A further variety is introduced in the action of the smoke and steam on calm nights.

On the evening of St. Patrick's Day all the searchlights were screened with green; not only the towers but every flag in the Exposition took on a new aspect.

Orange in various shades was the prevailing color for the evening of Orange Day and on the ninth anniversary of the burning of San Francisco the Exposition was bathed in red, with a strikingly realistic demonstration of the burning of the "Tower of Jewels."

High pressure gas lighting plays an important part in street lighting in the foreign and State sections; low pressure gas for emergency purposes, and gas flambeaux for special effects.

The accompanying illustrations suggest some idea of the illumination, but the addition of color is absolutely necessary to convey anything approaching a correct impression of the night pictures of the Exposition.

Strength of Wireless Signals

In a recent lecture delivered by Prof. Marchant at the Liverpool University before the Institution of Electrical Engineers he described an apparatus that he had used to measure the strength of signals received from distant places, and he showed by diagrams how the strength was influenced by atmospheric conditions. Between two stations lying nearly northwest and southeast of each other the strength of signals during the daytime varied within comparatively narrow limits. The ratio between the night and the day strengths varies with the time of year and also from day to day of any given month. On the evening of a fine, clear day the improved strength known as the "sunset effect" really occurs about three quarters of an hour after sunset, and it varies with the weather conditions. When rainy conditions prevail the strengthening of the signal after sunset is much less marked. The variations during the night are relatively great, and occur within the space of a few minutes.

Electrometallurgy—I*

Modern Methods for Producing and Refining Various Metals

By Joseph W. Richards

I wish to clear the ground first with a few advance remarks as to what electrometallurgy is. One definition of metallurgy is, "The art of making money out of ores." The technical definition is, "The art of extracting metals out of ores and refining them to the purity required by everyday use." Metallurgical operations are mostly chemical operations. Ores, with a few exceptions, contain the metals as compounds, and not in their native state. Therefore, it is usually a matter of decomposing the compound, as easily and cheaply as it can be done, by means of chemical reagents. Electrometallurgy is the art of utilizing the electric current in obtaining metals from their ores, or in refining them for industrial purposes.

The main divisions of electrometallurgy are, first, the electrolytic methods, and, second, the electro-thermal.

I. Electrolytic Methods.—1. Aqueous solutions: (A) Soluble anodes—electroplating, Au, Ag, Ni, brass; electro-refining, Cu, Pb, Ag, Au, Bi, Sb, Zn. (B) Insoluble anodes—extraction from solution, Cu, Zn, Au, Ag; cathodic reduction, Pb. 2. Fused salts (electrolytic furnaces): (A) Simple salts, Na, Ca, Mg, Ce, Zn; (B) solutions in fused baths, Al.

II.—Electro-thermal Methods (Electric Furnaces).—1. Fusion of metals or alloys—steel, brass, bronze, aluminum. 2. Reduction of compounds to metals or alloys—B, Si, Mn, Zn, ferro-alloys, pig iron, pig steel.

Electric current can be utilized for electrolytically decomposing chemical compounds. The electro-thermal method is that in which the current is used for its heating power only, and in which some other agent does the decomposing. These two are very distinct from each other, and I will spend a few minutes in emphasizing the difference between them.

In the electrolytic method you depend upon the electrolytic decomposing power of the current. You necessarily have to use a direct current except where the electric cell itself rectifies the current, which is very exceptional. In all practical electrolytic operations, only direct current is used. In electro-thermal work, where the current is used for its heating power only, direct current or alternating current may be used. Alternating current is cheaper and does not give the indirect effects that a direct current will give, for with direct current in an electric furnace you usually have undesired one-sided effects at the electrodes.

In the electrolytic furnace, the amount of useful work done, as measured by the amount of the product, is proportional to the amperes of the current which pass, according to the laws discovered by Faraday. When you are passing a current through an electrolytic cell, the amount of product is independent of the volts which may be expended on the cell, and is dependent only upon the amperes. It is only secondarily that the volts used affect the amount of product which can be obtained by forcing through more amperes. It is easy to calculate the theoretical amount which you should get at 100 per cent ampere efficiency upon the amperes flowing through any electrolytic cell.

In electro-thermal work, the heat-energy of the current is that which is utilized, and the heat effect is proportional to the amperes multiplied by the volts, so that the product will be proportional to and determined by the amount of energy which is expended upon the furnace as measured by the Kilowatt hour meter. The two processes are thus seen to be essentially distinct in these two fundamental ways. A third distinction may also be drawn between them—that in the electrolytic apparatus you must have an anode and a cathode arranged for proper electrolysis, and proper arrangements for the escape of the gaseous products at the cathode. In the electro-thermal methods you have no such distinction of parts. There may be electrodes, or the terminals or poles; but they are not positive and negative, they are not anode and cathode, and there is no arrangement of the cell which copies or duplicates the electrolytic arrangement which is necessarily part of an electrolytic operation.

I will discuss now why the electrolysis of fused salts is sometimes classed erroneously under the electric furnace methods. Fused salts generally conduct current freely. Their order of resistivity is that of a well-conducting aqueous solution like the best conducting sulphuric acid, something like one to three ohms per centimeter cube. When you pass the current through and decompose fused salts, the operation is primarily electrolytic—the decomposition of a fused salt to obtain its ingredients. However, you cannot pass an electric current through any solution, or, in fact, through any material, without generating some heat by the passage of the current. If you electrolyze with an intense current you generate much heat, and you may reach a point where the internal heat generated by the passage of the current is so large as to keep the electrolyte melted without the assistance of the external heat with which you started the operation. By running the operation with an intense current, it is possible to get the salt melted, and keep it so, without the aid of electrolysis, thus incidentally generating enough heat to keep the salt liquid at the temperature at which you run—300 deg., 400 deg., or 1,000 deg. Cent.—such as when producing aluminum, etc.; and by regulating the current you can keep the temperature just at the desired point. Many writers have been muddled on this point, and have thought that when outside heat is dispensed with, you then have a furnace, and they have classed these with electric-furnace processes. That is taking them away from where they properly belong. The fact that the operation is essentially electrolytic is not affected by the fact that the heat generated partly suffices to keep the bath melted, and whether the heat generated keeps the bath melted, or whether you have even to cool it down, that does not affect the classification: it is not an electric-furnace process. I would ask you, when you read about electrometallurgical processes, that you will bear that in mind—that the electrolysis of fused salt, when the current supply is sufficient to keep it fused, is necessarily an electrolytic operation. Some people think that when you are conducting an operation requiring a higher temperature than the ordinary one, you necessarily have an electric furnace. This difficulty has been solved by using the term "electrolytic furnace" for an operation of this kind, where the electric current performs electrolysis and also supplies all the heat necessary to keep the salt melted.

Taking up now the different methods of electrometallurgy, starting with the use of aqueous solutions among the electrolytic methods, when the only source of electric current was the battery, the plating of silver, brass, etc., and other metals by means of an aqueous solution and electric current was the only branch developed. Elkington brothers, in England, were the best known platers of gold, silver, and other metals, using aqueous solutions to do electroplating. According to my definition, electroplating with pure metal used as an anode would not be included in electrometallurgy, and I should say at the present time that electroplating with a pure metallic anode is not an electrometallurgical operation in the strict sense. I mention this because in the early days, when the battery only was used as a source of current, electroplating was called electrometallurgy. In Mr. Shaw's first book, he assumes that electrometallurgy means nothing more than the plating of the metals, the duplicating of medals and coins, starting with a pure metal as anode, and simply changing its form and plating it over. From the old books up to the present you will find much in them about electroplating, or, in general galvanoplastics, the art of changing the form of a metal. Elkington Brothers, who were plating gold and silver, were the first to utilize this principle for refining copper, away back about 1865. When the first dynamo was invented—the first machine of Wilde—there arose the possibility of using impure copper as an anode, and plating out pure copper, thus saving all the gold and silver contained in the impure copper. That was the first process by which it was possible to extract gold and silver from the metallic copper when they were present in very small amounts, and the process owed its commercial success to treating cheap impure copper, saving the gold and silver, and at the same time obtaining a very pure copper at the cathode. That is a real electrometallurgical operation. It has a few fundamental principles, which I will set forth as concisely as I can.

To electrolytically refine impure metal, you must choose as electrolyte a soluble salt in solution—such that the actual metal you desire to get will go into the solution—and then you must use a depositing current of such quality and quantity that you deposit only the desired metal out of solution. When you take impure copper as anode, and thus electrolyze it, there remain undissolved, at the anode, the gold, the silver, the platinum, little specks of slag and matte, and particles of copper, which drop to the bottom. This anode mud will frequently be 50 per cent copper and 30 or 40 per cent silver and gold. The iron, nickel, zinc, cobalt, tin, and a number of other metals have gone into the solution. The current-density at the cathode must be high enough to deposit the copper, but low enough to let the impurities accumulate in the solution, whence they have to be removed by other means. These principles are the foundation of the entire copper-refining industry, by means of which about 900,000,000 pounds of copper per year are refined for use in this country, the value running over one hundred millions of dollars. Similar principles are used for refining lead. For instance, Dr. Keith, of Philadelphia, worked out a very satisfactory laboratory process for refining lead many years ago. It was not satisfactory commercially, however; but in later years the problem has been solved by Mr. Anson G. Betts, and there are two or three such plants in operation in this country and abroad giving us a lead of very high purity, free from silver and gold, and particularly free from bismuth, which is one of the most difficult elements to get out of lead by ordinary refining processes. Bismuth remains behind in the slimes in such shape that it can be purified, and this process has increased very greatly the output of bismuth in this country. The lead is so free from bismuth that it commands a high price, being particularly desirable in the manufacture of white lead, for a trace of bismuth in white lead spoils its color.

Another element which is being electrolytically refined is zinc, which is more difficult to refine than copper or lead. There is also less margin commercially than there is for refining copper, and there is no gold or silver in it, whose saving pays for part of the operation, so the refining of it is not as profitable as that of copper.

The electrolytic refining of silver was first made practicable by Moebius. Taking as anode the silver bullion which comes from the cupellation furnace, the silver, copper, and iron go into solution, while the gold and platinum remaining are not dissolved. By properly regulating the depositing current, only pure silver is deposited. Silver of the greatest commercial purity is made in this way. Gold is electrolytically refined on the same general principles, but with differences in detail, by the Wohlwill process. The process was worked out at the Deutsche Gold und Silber Scheide Anstalt in Hamburg. A solution of chloride of gold, electrolyzed with a sheet of gold as anode, gives off chlorine into the air, and the anode is not dissolved. If you add hydrochloric acid to that solution, making a strongly acid solution, there comes a point where the escape of chlorine gets less and less, until its escape is prevented altogether, and the gold anode dissolves perfectly. That process was first put into operation in America, at our Philadelphia Mint. I believe the electrolytic plant has since been moved to the assay office in New York. The gold, platinum, and copper go into solution, while the silver forms chloride and remains undissolved. By using a proper depositing current, pure gold is obtained. The goldbeaters say they are getting much better results now from this commercial gold, because it is better than they were able to procure before by the acid chemical processes. The platinum is recovered from solution by a simple chemical operation, so that the platinum that used to stay with the gold and be lost is now saved.

Besides tin, lead, silver, copper, and gold, I believe there are other metals to which the electrolytic refining process is quite applicable. This is a large field, in which electrometallurgists are already working. Antimony and tin, for instance, have been worked on in this way. The general principles explained are applied, with differences in detail, to each one of the metals, enabling one to obtain the purest metals that have ever been put on the market. If you electrolyze a solution with an insoluble anode, you can extract the metal from the solution without replacing it by metal from the anode. There are a number of promising electrometallurgical processes included in this class of electrolytic processes.

1. When you dissolve the gold from gold ore by potassium-cyanide solution, the next problem is to get it out of solution. [illegible] chemical deposition, by means of zinc. [illegible]

* A paper read before the Engineers' Club of Philadelphia, U. S. A.

metallurgical method of extracting gold out of solution was used by Siemens and Halske in South Africa; but that method has had a hard struggle to compete with ordinary precipitation by zinc. Silver goes with the gold when it is deposited from a cyanide solution. If you look at the water in a copper mine, you will find it is frequently colored blue by sulphate of copper. That solution is usually run over scrap iron or pig iron to deposit the copper by a chemical reaction; but if you are handling solutions where iron is not available, it is possible to electrolyze it with an insoluble anode and throw down the copper, quite pure, on the cathode.

This year we have had news in the technical press of a very great development in this method of working in Chile. The Guggenheim's Chile Exploration Company has uncovered a large deposit of copper ore near Antofogasta which is soluble in dilute sulphuric acid. The ore is treated by dilute sulphuric acid, and, by electrolyzing the solution by insoluble anodes, the sulphuric acid for further treatment is regained. The main crux of that question was to find an insoluble anode which would not be attacked. Lead was used, but it forms lead peroxide, and gradually falls to pieces. A high-silicon iron was used; but that gradually falls to pieces. In Germany they are now casting magnetic oxide of iron (Fe_3O_4) into the shape of anodes, and using them successfully. They are about the shape of flattened baseball bats, hollow inside, with the walls a little over one-fourth of an inch thick. They are made in Frankfort-on-Main by the Griesheim Elektron Company. The Chile Exploration Company gave the Frankfort firm one order for $00,000 of these electrodes. It is interesting to consider that when they are immersed in the solution, the magnetite itself not being a good conductor, you would have considerable resistance in passing current down to the lower end. This is obviated by electro-depositing a shell of copper on the inside surface, fastening copper strips at the top to conduct the current into the inside shell, and then the only resistance which the current meets is about one-fourth of an inch of the magnetite to get from the inside to the outside. This work was described by Mr. E. A. Capellin Smith in New York before the American Electrochemical Society at its twenty-fifth general meeting in April last. That was the first public description of the operations in detail. That plant is designed to treat 6,000 tons of ore a day. An immense body of ore is available for treatment by this method.

You can get an idea of the importance of these methods of electrolysis with insoluble anodes from the few instances given. These magnetite anodes may also be quite useful in other electrolytic processes. In the generation of oxygen, for instance, they may find it practicable, for there has been trouble with anodes becoming corroded. I saw last Summer, in Butte, an operation of the same kind, of the Butte and Duluth Company, plating copper out from sulphate solution, and regaining the sulphuric acid for use again. The Phelps Dodge Company, which runs large copper mines in Arizona, has begun to study this method for its lowest grade of ores, and the main solution of this question rests on the use of insoluble anodes of fused magnetite.

(To be concluded.)

Cobalt Steel*

A New Material for Accelerating Machine Tool Speeds and Output

At the present time, when the need for increasing the output of our factories is so urgent, it is natural that engineers should be prepared to give attention to any practical suggestions that may lead to increased output.

One of these is that the merits of a comparatively new commercial product, cobalt steel, should be given a trial. Recent experiments have shown that tool steel made of a suitable alloy of iron, carbon, and cobalt is capable of speeding up to a remarkable degree any work in connection with the production of war material so far as turning, planing, slotting, drilling, and milling of iron and steel is concerned.

This special steel has been tested in America against a vanadium steel, the test being with ½ inch diameter twist-drill. The cobalt steel drill made 15,200 holes before the drill required to be ground, the hole depth being ½ inch through a malleable casting, and the drill running at 820 revolutions per minute under a large stream of oil. No other alloy steel drill could do better than 2,200 holes under similar conditions before regrinding. Such results are what would be expected after a scientific examination of the properties of alloy steels.

As Profs. J. O. Arnold, F.R.S., and A. A. Read, D.Met., state in the course of their well timed paper on "The Chemical and Mechanical Relations of Iron, Cobalt, and Carbon," read at the last meeting of the Institution of Mechanical Engineers, scientific opinion as expressed by Sir Robert Hadfield, a cobalt steel pioneer, is that the action of cobalt resembles that of nickel in raising the elastic limit and maximum stress of the material. The famous French metallurgist, M. Guillet, also found that "the presence of cobalt slowly raises the tensile strength and the elastic limit, while the elongation and reduction of area are diminished." The professor's own experiments proved that, with equal carbons, the tenacity of the steels, as measured by the yield points and maximum stresses, increases with the cobalt, while the ductility, as measured by the elongation per cent, correspondingly falls.

Cobalt, they find, does not form a definite solid solution, or cobaltide of iron like that formed by nickel, which, with only 0.1 per cent of carbon present, registers a maximum stress of about ninety tons per square inch associated with a reduction of area of 45 per cent. An alloy containing about 18 per cent of nickel and 0.6 per cent of carbon is so hard that it is impossible to machine it, whereas in a series of cobalt steels in which the carbon ranged from 0.62 to 0.03 per cent and the cobalt from 2.7 to 20.9 per cent, all the alloys, without any annealing, machined with the greatest ease.

The heat treatment of cobalt steel is simpler than that of any other high-speed tool steel. Thus the forging of tools is done at a yellow heat, and hardening is effected merely by heating up the tool to a white heat and allowing it to cool in the open air. Super heating to a fusing point is entirely unnecessary with cobalt steel and quenching in the usual media, such as air-blast, tallow, whale or linseed oil, molten lead, petroleum, or water, is not required. By obviating heating the tool up to the fusing point it is clear that grinding costs will be considerably reduced.

The Germans have recognized the merits of cobalt steel, and in a report just published by the Manchester Association of Engineers on "Past Experimental Work on Cutting Tools" we find Prof. G. Schlesinger of Charlottenburg arriving at the conclusion that "the employment of cobalt in the production of high-speed steels is followed by a remarkable increase in the cutting power and durability, without increasing the purchasing price above the average market price," which is about 3s 9d per pound.

How cobalt steel may be produced, according to Profs. Arnold and Read, is by melting together in suitable proportions ingots of pure cobalt, Swedish bar iron and Swedish white iron, afterward adding pure metallic manganese and aluminium ten minutes before teeming. In their recent experiments, to which reference has already been made, the steels were cast into square molds the ingots afterward being re-heated and hammered down into 1 inch round bars.

The advent of cobalt as a most valuable engineering material affords another example, along with tungsten and molybdenum, of the way in which what may be termed "chemical curiosity" metals have come to be of great industrial importance.

Until a few years ago cobalt had little use beyond forming the base of the pigment known as cobalt blue. In fact, as recently as 1912 a standard scientific work of reference could only record that "metallic cobalt is not at present used to any extent in the arts, though its utility is becoming more fully recognized."

The metal which is similar in properties to iron has a brilliant silver white appearance when polished, and like iron is very magnetic, being, in fact, next to iron on the list of magnetic metals. It melts at 1,490 deg. Cent. as compared with 1,520 degrees for iron, while its specific gravity of 8.5 is well above that of iron which is 7.8.

Canada is the world's principal producer of cobalt, practically all the cobalt of commerce emanating from the neighborhood of the town of Cobalt, which is situated in North Ontario near the shores of Lake Timiskaming. The deposits, which were only recently discovered, are immensely rich also in silver.

At first the owners of the deposits in Ontario did not trouble much about the cobalt, though this often amounted to as much as 18 per cent of the total and it was regarded rather as a nuisance, as it interfered with the silver extraction. It soon became obvious however, to the Canadian Department of Mines that cobalt had a new economic importance in view of its effect on steel. The director of the department, Dr. Eugene Haanel, therefore had an investigation made into the methods for preparing metallic cobalt from the oxide. The results of this investigation have recently been published, the necessary researches having been made at the School of Mining in Queen's University, Kingston, Ontario, in the course of which considerable quantities of pure metal were satisfactorily produced by one or other of the four methods adopted.

PREPARATION OF THE METAL

These methods are all based on the reduction of commercial cobalt oxide, the reducing media in the four methods being, respectively, carbon, hydrogen gas, carbon monoxide gas, and aluminium. In the case of carbon, which is heated with the cobalt oxide in a crucible by electricity, it was found possible with a small laboratory plant to reduce enough oxide to make 50 pounds of the metal in an eight hour day with the furnace absorbing 12 kilowatts. Thus, on a commercial basis, the power charge for effecting this reduction would be small. The hydrogen reduction experiments consisted in placing an alundum boat, containing a weighed amount of dried cobalt oxide, in an electric resister furnace, maintaining its temperature therein constant for a definite length of time, during which a stream of hydrogen was passed through the furnace. It was found that the reduction to metallic cobalt takes place very rapidly at all temperatures above 500 deg. Cent., and the method is especially recommended for the production of moderate quantities of very pure, carbon free cobalt for special purposes, just as it has been used for the production of metallic tungsten.

The carbon monoxide experiments differed but little in general outline from the above, except in the nature of the gas. The reduction took place very quickly after a temperature of 600 deg. Cent. had been reached. Where producer gas is available it should offer a cheap and efficient means of producing large quantities of pure metallic cobalt from the oxide.

The aluminium method of cobalt production is probably the most interesting, but hardly the cheapest though it is practically essential when absolutely carbon free metal is required. To effect the desired reduction, 5 to 10 pounds of finely divided cobalt oxide is mixed with powdered aluminium, and the whole placed in a conical welding furnace of the Thermit type. The reaction is started by lighting a fuse of finely divided aluminium and potassium chlorate rolled in a piece of tissue paper. The furnace fires with great violence and the contents are raised to a white heat.

The aluminium reduces the cobalt oxide and oxide of aluminium is formed. One pound of aluminium will reduce and melt in this way two pounds of metallic cobalt. Therefore there is a charge of about 9d in the form of one pound of metallic aluminium for the power needed to reduce and melt two pounds of metallic cobalt. There might, of course, be some return for the fused aluminium oxide resulting from the process, but even allowing for this the costs are high compared with the carbon and carbon monoxide methods of reduction, to which reference has already been made.

It is obvious that the heating costs must be high by the aluminium method, for heat is being supplied at a temperature greater than 2,100 deg. Cent., that is at a temperature far in excess of what is required for the reduction of the oxide and the melting of the metal, and with consequent attendant increased losses due to conduction and radiation.

The initiation of these investigations as well as the thorough manner in which they were carried out reflects great credit on the Canadian Department of Mines, and it is to be hoped that the enterprise will be rewarded by an ever increasing demand for a metal of which the empire appears to possess unlimited supplies, and of which the use may be expected to grow rapidly now that engineers are realizing the value of cobalt steels.

* The Scottish Daily Telegraph.

Measurement of Short Intervals of Time

In conducting delicate scientific investigations it is frequently necessary to be able to measure very short intervals of time, or to be able to break two separate electric circuits in succession, but with a definite, predetermined interval of time that can be accurately controlled and reproduceable. How this can be done is explained by J. Coulson in the *Phys. Rev.*, 4 Ser. 2, P. 10, where he describes a simple apparatus that he has devised. The apparatus is based on the principle that if a massive weight, falling freely under gravity strikes a collar on a metal rod which is supported vertically, an elastic wave or impulse travels out along the rod in each direction from the collar with a finite velocity. If the impact takes place at the middle of the rod, these waves will, of course, reach the ends of the rod at the same time. If, however, the point at which the impact occurs be not at the middle of the rod, the impulses will reach the ends at times that differ by an interval which will depend on the path-differences. In this way controllable time intervals extending over a considerable range may be secured, and can easily be measured with the aid of proper apparatus.

Gyroscopic Phenomena

A Popular Presentation of a Perplexing Phenomenon

By Bert L. Newkirk

The useful applications of the gyroscope have become so numerous and so important, especially within the last two years, that well-informed men and women are asking for non-technical explanations of gyroscopic phenomena. The following is an analysis of the seemingly anomalous behavior of the gyroscope into three simple phenomena, with an effort to show that each is

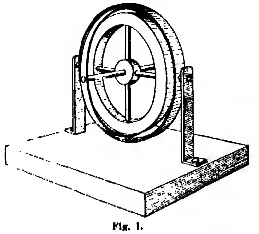


Fig. 1.

a perfectly natural occurrence, in full accord with every-day experience.

Any rapidly rotating body is a gyroscope, but a well-balanced wheel mounted in gimbal rings, as shown in Fig. 1, is best adapted to the present purpose. The mounting permits the axle to point in any direction and to turn about any line which passes through the center of the wheel. When the wheel is not spinning we may, by exerting a slight pressure with the fingers at the end of the axle cause it to move in various directions and assume positions as shown in Figs. 2 and 3. Naturally the end of the axle moves in the direction in which we push it, and it should move very easily, for the apparatus is worthless for demonstration unless the pivots about which the rings turn are nearly frictionless.

If now the wheel be made to spin rapidly and an effort be made to move the axle as before the apparatus will seem perverse. The most vigorous resistance will be offered to any attempt to change the direction of the axle. If we strike the end of the axle or the ring near it with a club or hammer we may use force enough to damage the mechanism without producing any considerable change in the direction of the axle. If we proceed more gently and exert a steady pressure as indicated in Figs. 2 and 3, motion will occur, but it will be mainly in a plane at right angles to that in which we push. The vigorous resistance and this seemingly anomalous motion are the two features of gyroscopic action that play the important roles in the useful applications. We call them *gyro-resistance* and *precession*. The last of the three phenomena mentioned above is the vibration or jar that occurs when the end of the axle or the ring near it is struck while the wheel is spinning. This jarring might seem to arise from the lack of rigidity of the mounting, and it is indeed very much like the vibration of a stiff spring; however, the effect is due to gyroscopic action and is called *nutation*. It takes the form of a very pronounced wobble if the end of the axle be given a quick push when the wheel is spinning at a slow rate.

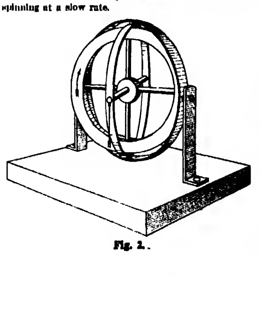


Fig. 2.

An example of the effect of gyro-resistance and precession is shown in Fig. 4. The axle is supported at one end and the weight of the body exerts a force tending to change the direction of the axle. Gyro-resistance prevents the fall of the wheel and frame and the precessional motion produced by the steady force of gravity occurs as indicated by the dotted line.

The common top, Fig. 5, offers another good illustration of the phenomena we are considering. The force of gravity, tending to overturn the top, is opposed by the gyro-resistance, and the precession occurs in a constantly changing direction, but always at right angles to the direction in which the top would fall if it were not spinning. The chattering of the top when it comes into contact with the wall while spinning is due to nutation.

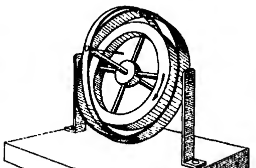


Fig. 3.

The phenomena described above are applied in the Brennan mono-rail car, the gyroscopic compass, a device to prevent the rolling of ships at sea, and in a number of other devices that play a more or less prominent part in human affairs. Especially worthy of mention, perhaps, is the fact that the dreaded submarine torpedo owes its effectiveness in large part to its gyroscopic steering mechanism.

I shall now attempt to show that these phenomena are perfectly natural and fully in accord with the facts of every-day experience. In the first place, since the phenomena appear only when the wheel is spinning, we conclude that the portion of the material which is

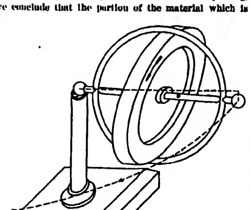


Fig. 4.

in rapid motion is responsible for the observed behavior. Second, since the rapidly moving material is almost entirely in the rim of the wheel, we look to that for the explanation. The forces which we apply at the end of the axle are transmitted by the spokes of the rim and there meet the resistance noted and produce the precession and nutation. Holding this fact in mind, let us stand at the near end of the axle (Fig. 1) with our eyes near the rim and looking toward it. Let us for the moment imagine the rim replaced by a series of separate bodies flying past our vision like bullets from a machine gun, each constrained to move in a circular path by a wire attached to some point below.

Now suppose that each of these bullets were struck a blow in the direction of the line of vision as it passes the eyes. The effect would be simply to deflect the stream slightly. The bullets, glancing off, would continue to move in circular paths as before, but in a slightly different plane. If the series of blows should cease as soon as each of the bullets had received one blow, then the whole series would be revolving in a plane slightly different from that in which they moved originally. Repeated series of blows would result in corresponding changes of the plane of motion. This is

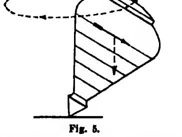


Fig. 5.

really precession. A lifting force, for example, exerted upon the end of an axle of a spinning wheel is carried by the spokes to the particles of the rim and acts upon them as the series of blows acts upon our stream of bullets. In both cases the result is a change in the plane of rotation. The bullets, though struck repeatedly in the direction indicated by the arrow, return always after completing a revolution to the point at which they were struck. Thus, the stream does not yield in the direction of the blows, just as the axle seems not to yield in the direction in which it is pushed. The resistance is gyro-resistance in both cases and the gyro-resistance seen from this point of view is only an example of the familiar resistance of streams of particles (water, for example) to any deflecting force. If a stream of water issuing from a nozzle under a high head be struck with a club, the club will rebound as though the stream were solid. (See Figs. 6 and 7.)

I have devised a simple apparatus to illustrate these effects. On account of the mechanical difficulty of causing a stream of bullets attached by wires to a central point to revolve rapidly without confusion, I have reduced the number to two and mounted them so as to balance each other and upon a universal joint so that they may revolve in any plane (Fig. 8). If these be set into rapid revolution in any plane and a heavy block of wood be held so that they will strike it a glancing blow as they pass a certain point in their path the result will be a gradual shifting of the plane of revolution, as explained above. The resistance which the revolving masses offer to the force exerted by the person holding the block illustrates the gyro-resistance.

We have disregarded the rigidity of the rim in thinking of it as a stream of bullets. Due to this rigidity, the lifting force impressed upon the end of the axle is not all imparted to the particles of the rim as they pass the highest point of the path, but it is exerted upon them continuously. The result is, however, precessional motion in either case. The rate of precession produced by a given force at the end of the axle of a wheel is the same as would be produced by an equivalent series of blows acting upon the rim or upon a stream of separate bodies of the same aggregate mass.

The nutational vibration or wobbling is a direct consequence of the rigidity of the wheel. For reasons to be explained below, the spinning wheel and axle do yield slightly to a force applied at the end of the axle. This yielding to the impressed force is called the dip. For example, if the rapidly spinning wheel of Fig. 4 is

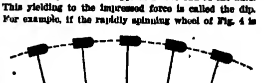


Fig. 6.

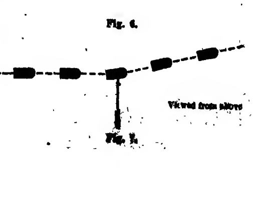


Fig. 7.

placed upon the stand with the axle horizontal, and released, the wheel and frame will dip slightly into the position shown in the figure and precess so that the axle describes the surface of a cone of large angle. The illustration very much exaggerates the amount of the dip, which is usually so minute as to escape notice. When a wheel is spinning rapidly in gimbal mounting (Fig. 1) any force exerted to change the direction of

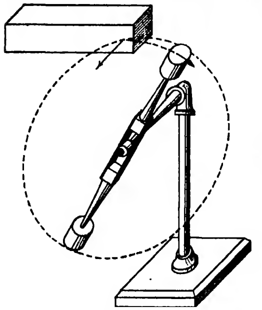


Fig. 8.

the axle will produce a slight dip in addition to the precession. This yielding or dip is very much like the yielding of a spring when stressed. If the wheel is spinning very rapidly it yields like a stiff spring, but if the spin is slow the yield is like that of a weak spring. The amount of the dip is very nearly proportional to the force applied.

The nutation is simply a fluctuation of the dip. When a load is suddenly dropped upon or hung from a spring there follows an oscillation, which dies out gradually. In a closely analagous manner a force suddenly applied to the end of the axle produces a dip of fluctuating magnitude, the oscillations gradually dying out, as in the case of the elastic vibrations. If the force be great, or if the wheel be spinning slowly, these nutational vibrations are conspicuously evident in the form of a wobble of the wheel, but more frequently they are noticeable only as a rattle or jar which disappears within a fraction of a second. The actual motion is a combination of the nutation with the precession. The wobble of a spent top is of this sort. A heavy gyroscope model in gimbal mounting will show it to advantage if the wheel be made to spin slowly and a weight be attached suddenly to one end of the axle.

Let us now inquire into the reason for the dip. If the rim were composed of separate sections like the series of bullets considered above, each would keep strictly to its path until it reached the top, when a sharp blow would produce a sudden deflection; but the wheel being in fact quite rigid, it is as though the single sharp blow which struck the bullet at one point in its path were replaced by a multitude of minute blows rained upon it during the whole course of a revolution. Consider a small section of the rim as it moves from A to B, Fig. 9. The upward force applied at the end of the axle begins at A, let us say, to produce a deflection, and continues to exert such an influence as the section moves forward, so that by the time it reaches B it is somewhat to the left of the position it would have occupied if the force were not acting. The whole circumference being acted upon in an analagous manner, the result is a slight tipping or yielding of the whole wheel to the force applied at the end of the axle.

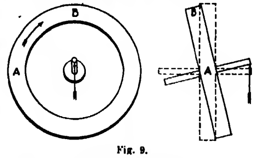


Fig. 9.

The three fundamental phenomena of gyroscopic action, namely, gyro resistance, precession, and nutation, appear therefore as perfectly natural events thoroughly in accord with common experience as soon as we look to the rim of the wheel as the dominant part of the mechanism and remember that it is in rapid motion. The precession is a continuous deflection or "glancing off" of the particles composing the ring, the gyro-resistance is the resistance always encountered when a rapidly moving body is turned out of its course, and the nutation is the vibration which results from a blow or pressure suddenly applied to a yielding body.

Color Photography

While progress is being made in the technique of the production of colored photographs, the reproduction of photographs in natural colors, in the strict sense of the phrase, does not appear to advance. Yet the progress achieved in color photography must not be under-rated. Discoursing on "Color Photography," in two lectures delivered at the Royal Institution at recent meetings, Prof. W. J. Pope, F.R.S., of Cambridge, was able to exhibit many beautiful specimens, and to point out that the art is rendering valuable assistance to science. Dr. Pope confined himself to the general features of the problems, without entering into the chemistry of the processes and the intricacies of the technique. The problem of photography in natural colors presents itself under two aspects, that of the artist in black and white, and that of the color artist. With regard to the latter aspect, Prof. Pope pointed out, the difficulty was that the color appreciation of the eye differed from that of the photographic plate. The sensitiveness curve of the eye had a high peak in the yellow, and did not extend beyond the violet; the sensitiveness of the photographic plate was almost outside the range of the visual spectrum, and did not reach the yellow at all. Thus on a black-and-white photograph of daffodils the deep orange-yellow of the heart of the flower came out almost black, while the pale yellow of the petals appeared nearly white. Forty years ago Vogel had shown how the addition of certain coloring matters (sensitizers) to the emulsion of silver salts would render the plate more ortho-chromatic, and Abney and others had carried those studies further — so far, indeed, probably, as we could go in this direction. The sensitiveness curve of the panchromatic photographic plate now nearly embraced that of the human eye, but the peaks of the curves did not coincide; there was too much blue intensity in the photographic image. To correct this defect, Eder had interposed a yellow screen in front of the lens, which stopped the blue rays, and, with the aid of panchromatic plates and of color-filters, the effects of colors could now be reproduced in monochrome with fair fidelity.

The foundation upon which the reproduction was based had been given by Clerk Maxwell in the Royal Institution in 1861, though Maxwell's results, obtained so long before the days of ortho-chromatic plates, were poor. The principle was the three-color theory of Young-Helmholtz. The light had to be split up into its parts; each part had to be photographed separately, through screens of blue-violet, green, and red, and the positives had to be superposed. When light was sent (in the demonstration) through screens of these colors, and three disks in these colors projected, the overlapping three colors gave white, while the overlapping red and green gave yellow, the blue-violet and red together gave pink, and the blue-violet and green gave a sky-blue; these were additive color effects. But when light was sent through disks of glass stained with these latter complementary colors, or when disks were painted in the complementary colors, so as partly to overlap again, the three colors together gave black, the sky-blue and yellow gave green, the pink and sky-blue gave blue-violet, and the yellow and pink gave red; those were "subtractive" effects. White light sent through transparent screens of the colors in the last instance would, of course, appear in the complementary colors, and the black spot would shut out all the light and would, therefore, appear white on the negative. To work on this principle complicated cameras provided with three lenses were not needed; a plate was exposed behind each of the filters in a camera, as it would indeed be difficult to use one camera with three lenses, since the three negatives would not be taken from exactly the same spot, and would not quite coincide, therefore. Transparencies from the three negatives were illuminated by their own colors (i. e., the photograph taken through a red screen was illuminated by the light through the same red screen) and superposed. But when prints made from these negatives were to be superposed they had first to be colored in the complementary colors.

The Du Hauron, Ives, Sanger-Shepherd, and other processes were based upon this principle; they gave excellent results, but the superposition required very great care. Hence other processes had been tried.

Nearly 20 years ago Prof. Joly, of Dublin, introduced a new method. He ruled a glass plate with a series of parallel lines, red, green, and blue, repeating the colors in the same sequence all over the plate or screen, which was then divided into fine stripes of colors. This screen was put in front of the plate when the photograph was taken, and when the contact transparency from the negative was examined through a screen in complementary colors, the colors came out very well, especially the whites; the greens were less satisfactory. On the original plates of Joly, exhibited by Dr. Pope, the greens were bad; but with modern screens, which were ruled in very fine lines and fitted with means for securing an excellent register, artistic effects were realized. The horizontal or vertical stripes were faintly visible, however, in the magnified projected lantern images, unless the focussing was intentionally spoiled to a slight extent. The stripes could successfully be replaced by squares in the three colors; but the exact registering remained a difficulty.

The autochrome process disposed of this difficulty. In these the screen was permanently attached to the photographic panchromatic film, and remained in contact with it all through the photographic process. For the strips or squares or regular geometrical patterns of the former processes, grains grains, dyed in the three colors, were substituted. The grains, dyed red, green, and blue-violet, and properly mixed, were uniformly distributed over the glass plate, rolled into some adhesive substance, dried, and then coated with the photographic film. The plate consisted of very small patches of red, green, and blue. The plate itself looked whitish; the magnified projection showed the colored patches in irregular arrangement. On exposure, light would pass through the glass front, through the starch grains on to the sensitised film. Only red light would pass through a red grain, the other light being stopped. Silver would therefore be deposited under the red patch, corresponding to a red spot in the object, and the spot would appear dark and opaque after development. When this negative was held up to the light, little color would be visible, because the rays would now be stopped by the deposited silver; this silver had hence to be removed and reversal effected. The negative would then be exposed to light to produce a positive, which was again developed, and the color showed clearly after the second development. Each photograph gave only one print, however. Photographs of flowers, scenery, portraits in gay colors, reproductions of classical pictures, etc., were exhibited to show the beautiful effects realizable by this process. On the white parts of the images some colored spots could generally be distinguished by close examination, even in the not-magnified mirror images of transparencies. On the other hand, the gloss of the hair and the iridescence of butterfly wings were reproduced with remarkable fidelity, though the iridescence might not emanate from the same spot in the original (shown by the aid of an epidiascope) and the photographs, since the angles of the incidence of light were not the same. Prof. Pope drew particular attention to his photographs, obtained by the various processes alluded to, of pathological objects and of microscopic sections of rocks and crystals taken between nicol prisms in polarized light. That the colors of the stained pathological preparations were not always quite faithful did not matter so much, because the chief point was, of course, to bring out and to fix for future re-examination all the details revealed by the microscope. The amazing complexity of rocks, like granite, dolerite, etc., was fully brought out by polarized light in all its brilliancy of colors.

Leaving technical details to some future occasion, Prof. Pope mentioned in his conclusion the attempts made to do without colored screens of any kind. Prof. Wood had obtained some success with gratings. When the diffraction spectrum of a grating was looked at in a particular direction, some particular color was seen, which depended upon the incidence and on the fineness of the ruling. When three pictures were taken through gratings of three different degrees of fineness of ruling, colored photographs could be obtained; they were not suited for projection by the lantern, but only for individual examination. This method might be perfected.

A further development in photographic color processes was exhibited at the Royal Photographic Society on Tuesday last. It is known as the Kodachrome process, and consists in making two negatives of a subject through red and green light filters; the plates, after development, are bleached and stained, the one with a red dye, and the other with a green color. The plates thus obtained are clamped together and viewed as a transparency, very beautiful results being obtained.—*Engineering.*

Benzole is very extensively used as fuel for the motor transports of the German army, and immense quantities are required. It is reported that the Association of German Benzole Manufacturers of Bochum has contracted with the government for the whole of its requirements. In the Dortmund district it is said the coke ovens are still producing 5,400 tons of benzole a month.

Tides in the Earth's Crust*

And the Elasticity of the Globe

By Alphonse Berget

When we study in detail the movements to which the earth is subject, we are astonished at their number and diversity. Apart from its rotation around its axis and its revolution in an elliptical orbit around the sun, the earth is subject to other movements, the more important of which are the precession of the equinoxes and nutation. It has recently been discovered that the terrestrial poles are not fixed within the earth, but undergo displacements of the order of magnitude of the tenth of a second of arc; moreover, the solar system as a whole, including of course the earth, is moving through the heavens in the direction of the star Vega, at a speed of about *12 miles a second*. Thus there are, altogether, six movements to which the earth is subject.

In the study of these six movements, however, we suppose the earth's crust itself to be rigid and to preserve perpetually the form of a flattened ellipsoid imposed upon it by universal attraction and the centrifugal force due to its movement of rotation.

Nevertheless the question arises whether this assumption is correct; i. e., whether the crust of the earth does not itself undergo periodic deformations, and, if it does, under what influences these deformations are brought about. Lord Kelvin was the first to investigate the "elasticity of the earth," and to place before the world the question whether the earth's crust does not constitute an elastic body the shape of which is continually modified by external forces, the principal of these being the attractions of the moon and the sun, which, as is well known, produce in the ocean the phenomenon of the tides. In a word, does not the terrestrial crust have its own tides, which periodically alter its form? Such is the question to be considered.

The attraction exercised by the moon and the sun on any movable body on the earth's *surface*, such, for example, as the bob of a plumb-line, in a state of rest, varies continually in magnitude and direction with the position of these two bodies with respect to the earth. The prolongation of the plumb-line should, therefore, describe a certain curve on a sheet of paper fixed beneath it on the ground. Hence the question resolves itself into one of "deflections of the vertical." Let us try to calculate this "lunisolar" attraction. At first thought one might suppose it to be considerable. The mass of the sun is about 325,000 times as great as that of the earth, while its distance from the earth is equivalent to 23,400 times the terrestrial radius. Computing the attraction, according to Newton's law, as proportional to the masses and in inverse ratio to the square of the distance, we find for the deflecting force acting on the plumb-line the equivalent of about 1/1300 the force of gravity. From this it would seem that the solar attraction causes in bodies on the earth an apparent loss of weight equal to 1/1300 of their weight.

This simple reasoning is, however, erroneous. We must not forget that the earth itself performs essential movements under this same solar attraction, in describing its elliptical orbit around the luminary. Now it is a fundamental principle in mechanics that a force once obeyed enters no further into the calculation unless allowance is made for the effect already produced by it. A heavy body suspended over the earth's surface and drawn away from the vertical by the sun's attraction moves along with the earth itself in response to this attraction. Hence there remains as a force effective in disturbing the vertical, only the difference between the attraction exercised at the surface and that exercised at the center of the earth. Calculating on this basis, the figure obtained is, for the solar attraction, only about 1/20,000 of that obtained in the previous calculation, and represents only the 26-millionth part of the force of gravity.

Let us now consider the attraction of the moon. The small mass of our satellite, which is only the eightieth part of that of the earth, is largely compensated, with respect to its attraction upon terrestrial bodies, by its comparatively small distance, for the center of the moon is distant from the center of the earth only thirty diameters of the latter. Making the same calculations for the attraction of the moon that we have just made for that of the sun, we find the perturbation in the weight of terrestrial bodies due to the attraction of our satellite to be about 1/12,000,000.

To the French astronomer, Victor Puiseux, we owe the first analytical study of this perturbative action. The astronomer Gaillot subsequently gave us a simplified form of the analysis and traced the theoretical curves which should be described on a horizontal sheet of paper by the prolongation of a plumb-line under the influence of lunar attraction, assuming an absolutely rigid earth. These curves are reproduced in the accompanying four figures, which shows the different forms of the curve corresponding to different values of the moon's declination. (Figs. 1, 2, 3, 4.)

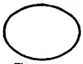


Fig. 1 - (Δ = 0)

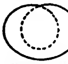


Fig. 2 - (Δ = 10°)

Fig. 3 - (Δ = 20°)

Fig. 4 - (Δ = 30°)

When these calculations were made known, many investigators were discouraged by the revelation of the minute effect to be measured. At the end of a plumb-line 100 meters long, an instrument which would itself be difficult to install under suitable conditions of stability, the deflection would be only about a hundredth of a millimeter. This easily explains the failure which attended the efforts of such physicists as Lord Kelvin in 1878, Bouquet de la Grye in 1874, G. and H. Darwin in 1879, d'Abbadie in 1881, and Ch. Wolf in 1883, to make direct measurements.

There is, however, another cause for the failure of such attempts, and this arises from the elasticity of the terrestrial globe. The calculations serving as points of departure in all the experiments above mentioned were made on the hypothesis that the earth is an undeformable sphere and absolutely rigid. The situation is completely changed if we suppose the earth to possess a certain elasticity which enables it to undergo deformations in obedience to the lunisolar attractions. The earth's crust would then behave like the water which forms the free surface of the sea; a protuberance would be formed and the crust would be subject to true tides.

It must, on the other hand, be stated at once that the deformations produced in the earth by the two celestial bodies in question may be essentially different in nature; some of them act only on the superficial layers of the earth, while others act on the whole globe. In the former case they produce an *apparent* deflection of the vertical, for, in reality, it is the surface layers themselves which, affected by these deformations, are displaced with respect to the vertical, while the latter remains unchanged. The principal reason for these apparent deflections is the heating of the external layers of the earth's crust by the sun's rays. The solid crust of rock enveloping the earth is a poor conductor of heat. Hence only the part of the earth turned toward the sun feels the warming influence of the solar rays, which expand and deform it, while the opposite side of the globe is heated and deformed in its turn twelve hours later. Moreover, also on account of the poor conductive properties of the earth, the distortions caused by surface heating do not extend to a great depth. Since the heat of the sun is the principal cause of these apparent deflections, it follows that the latter must have a periodicity analogous to that of the solar movements; i. e., a diurnal period. On this will be superposed an annual period, due to the variation in the obliquity of the solar rays with the march of the seasons, which, in turn, depends upon the variation in the sun's declination.

But there are also real, as well as apparent, deflections of the vertical, and their cause is to be sought, not in local heating under the influence of the sun's rays, but in the attractions exercised by the moon and sun upon the matter constituting the whole globe. If the latter were rigid, the lunar and solar attraction could not produce any deformation in it, and the deflections of the vertical could be calculated by the methods above described. If, on the other hand, the terrestrial globe were wholly fluid, and if, accordingly, it behaved like a liquid and non-viscous sphere, the outer surface, like that of the ocean, would change its shape every moment under the attractions of the sun and the moon. Under such conditions the physical observation of the deflection of the vertical would be impossible; since, by definition, the vertical is always a line perpendicular to the surface of the ground. Moreover, it would be impossible to observe the terrestrial tide, owing to the lack of any fixed point of comparison. For the same reason the oceanic tide cannot be observed in the open sea, far from any shore.

Fortunately the truth lies between these two extremes; the earth is neither absolutely rigid nor absolutely fluid. Nevertheless, although it does not possess absolute rigidity, it has a considerable degree of "solidity." The state in which matter must find itself in the liquid central core of the earth, where it is subjected to colossal pressure, implies a compactness nearly akin to solidity. Basing his calculations on the known values of the precession of the equinoxes and nutation, Lord Kelvin was led to conclude that, considered as a whole, the earth must possess a rigidity comparable to that of steel. Hence we must admit that our globe, as a whole, is endowed with a certain degree of elasticity.

In virtue of this elasticity the shape of the globe must be modified every moment by the combined attractions of the sun and moon, at the same time that it undergoes local superficial deformations for the reasons above mentioned. Consequently, the deflection to be observed in the direction of the plumb line will be the difference between these two effects. The delicacy of the observation explains the ill-success attending earlier efforts to measure this deflection. However, some experiments of high precision executed in the laboratory of the International Geodetic Association have successfully put in evidence, not only qualitatively but also quantitatively, the deflection of the vertical. These experiments made use of an indirect method, based upon the prodigious sensitiveness of the instrument known as the horizontal pendulum.

The horizontal pendulum consists essentially of a horizontal rod fixed to a solid metal support by two vertical wires. The points of attachment of these two wires are not in the same vertical line, but in two vertical lines which can be shifted with respect to each other at will. The free extremity of the horizontal boom carries a weight to which is affixed a mirror, which, by reflecting a ray of light, serves to register the slightest displacements of the weight on a strip of sensitive photographic paper arranged to be unrolled by clockwork.

The apparatus being thus arranged and its support resting on a horizontal plane, the pendulum assumes a position of equilibrium, and this position is absolutely fixed for a given direction of the vertical. If, however, the latter becomes deflected, even in the slightest degree, the pendulum begins to oscillate. The law of its oscillation is, moreover, simple; its duration is the same as that of a vertical pendulum having a length equivalent to the vertical distance between the weight and the point where the straight line joining the points of attachment of the two wires, intersects the vertical line passing through the center of gravity of the oscillating weight. Evidently we may make this length as great as desired by shifting the points of attachment of the two wires that support the pendulum toward each other horizontally. Thus we have a horizontal pendulum oscillating as slowly as a vertical pendulum of great length.

The experiments just mentioned utilized two of these horizontal pendulums, the booms of which, in their positions of equilibrium, were at right angles to each other. The distance between the points of attachment in the two cases were such as to correspond respectively, as measured by their oscillations, to ordinary pendulums 175 and 117 meters long. The two booms were [illegible]

* Translated for the Scientific American Supplement from *Larousse mensuel*.

meridian of the place of observation, and their oscillations were recorded by the photographic device described above. Comparing the graphs thus obtained, and constructing, point by point, curves having for abscissas and ordinates the results deduced from the movements of the two pendulums, a curve was obtained which represents the displacements which would actually occur in the end of a plumb line under the effect of the lunisolar attractions. This curve was constructed for each day, and the results were grouped in periods of ninety days to give trimonthly means.

By this means it was possible to observe the existence of a deflection of the vertical in the direction of the meridian amounting to one-five hundredth of a second of arc. Moreover the trimonthly means showed the amplitude of the oscillation to be only half as great in Winter as in Summer. Thus we are clearly confronted with thermal effects, the cause of which is, as foreseen, the superficial heating of the ground by the rays of the sun. The effects of such dilatation mask completely those of the lunisolar attraction upon the pendulum.

It has been possible, however, to find observational evidence of the latter, by taking account of an essential fact. The period of thermal action is twenty-four hours, or diurnal, while that of the attractive action of the sun is twelve hours, or semidiurnal. This follows from the fact that the solar attraction is exercised in the same manner when the sun occupies either of two symmetrical positions with respect to a given diameter of the earth, and this occurs twice in twenty-four hours. By combining, two by two, the values of the deflections for each hour, and taking half the sum and half the difference of each pair, we obtain the desired result; for, in the half-sum, the thermal effect is naturally eliminated, since it is equal but of opposite sign for the two hours in question, while the attractive effect remains unaffected. On the other hand, the thermal effect is given by the half-difference, while the attractive effect disappears. In computing the lunar action, the separation of the two effects is easier, owing to the difference of period; the lunar period is 24 hours 50 minutes, as compared with the 24-hour period of the sun which gives the thermal effect.

One cannot but be struck by the similarity of "observed" curves to those calculated by Gaillot. There is, however, a slight difference between the two sorts of curves. The observed curves have a smaller amplitude than the theoretical curves, and this diminution of amplitude is about half as great in the direction of the meridian as in that of the parallel. The closed loop seen in the curves corresponding to high northern declination of the moon is due to the fact that the lunar tidal wave has two daily maxima; these maxima are equal if the moon lies in the plane of the equator, unequal if it lies north or south of it; and the further our satellite lies from the equatorial plane, the more pronounced is the inequality.

The conclusion to be deduced from these admirable experiments is quite definite: Our earth, considered as a whole, possesses a certain elasticity, of the same order of magnitude as that of steel; i. e., as to the deformations it undergoes, the globe behaves nearly the same as would a globe of steel of the same dimensions. It is most interesting to find that a consideration of the oceanic tides, the migrations of the terrestrial poles, and the precessional and nutational movements of the earth all lead us to assign to the globe a general elasticity of about the same order. This is a remarkable confirmation of the early ideas of Lord Kelvin.

The study of seismic phenomena leads us to an analogous conclusion. The original shocks which give rise to earthquakes are, indeed, transmitted in two different ways; viz., through the crust, and through the terrestrial spheroid as a whole. The propagation through the crust takes place at various speeds according to the nature of the material, and ranges between 150 and 800 meters per second. The latter speed is seldom exceeded. It is these movements in the crust that cause the folds and crevasses often observed after seismic phenomena of great intensity. On the other hand, the propagation of the same shocks through the globe as a whole takes place much more rapidly. When a strong earthquake occurs at any point on the earth, the most remote seismological observatories—distant, for example, 6,000 to 8,000 kilometers from the epicenter—are notified of it within a few minutes by the disturbance of their seismographs. Comparing the time of such registration with the actual time of occurrence at the point of origin, and taking account of the distance, we find that the propagation of the shock through the earth takes place at a speed of 10 kilometers per second; i. e., about 500 times the speed of an express train.

After the first registration, it is found that, at the end of some minutes, the seismographs begin to be disturbed and to register again. If, as in the previous case, we compare the time of this second registration with that at which the phenomenon really occurred, we find that these new seismic waves have traveled with a speed which is, in this case, not 10 but 5 kilometers per seconds; i. e., half the speed of the former series. Now the mathematical theory of elasticity furnishes a remarkable check on these observations. This theory, which, it should be remembered, is based on laboratory experiments, teaches us that if a sudden shock occurs at any point in an elastic sphere it will be transmitted to the whole mass in the form of waves. Moreover, the shock gives rise to two distinct series of waves, of which one series is transmitted at twice the speed of the other.

This is exactly what our observations show in the case of seismic shocks transmitted through the terrestrial globe as a whole. Moreover, if we introduce into our formula for elasticity the data of seismological observations, the unknown quantity being the general elasticity of the earth, we find for the latter a numerical value of the same order of magnitude as that of steel. Here we have a magnificent confirmation of the theory of elasticity, and an admirable agreement with the results obtained by other methods.

Thus it is possible for us to form a tolerably correct idea concerning the state of the igneous matters constituting the central core of the earth. Taking account of the "geothermic degree," i. e., the increase of temperature amounting, on the average, to 3 degrees per 100 meters, which prevails with increase of distance from the surface of the earth, science has been led to assign to the earth's crust a limiting thickness of from 60 to 70 kilometers, or about a hundredth part of the radius of the earth. Below this crust there must be materials the relatively high density of which compensates for the relatively low density of the surface rocks, with a specific density of about 2.5, in order that the general density of the earth may attain the density of 5.5 which it is known to possess. The density of the matter at the center must be approximately 10, and only the metals possess densities of this order. Hence the central core is composed of mainly metallic and ferruginous materials in a state of fusion, and at a temperature far above their melting-points.

How, then, shall we reconcile the liquid state resulting from fusion with the elasticity of the globe, which we have found to be comparable to that of steel?

It is only necessary, as Lapparent has pointed out, to consider the enormous pressures to which the materials constituting the core of the earth are subjected. If the earth were entirely composed of water the pressure at the center would be more than 500,000 atmospheres. As its density is 5½ times that of water, the pressure at the center must be more than 3,000,000 atmospheres. Now we cannot, from our laboratory experiments, the most daring of which have hardly attained pressures of a few thousand atmospheres, form any idea as to what may be the condition of metals, melted, it is true, but subjected to pressures of several million atmospheres. It is probable that the formidable compression to which these materials are subjected gives them a rigidity "practically equivalent to the solid state." Thus we explain the elasticity, analogous to that of steel, presented by our globe as a whole.

Camp Engineering—Water Purification

We hear so much of the work of mechanical and electrical engineers in connection with the war that that of civil engineers does not always receive the appreciation it deserves.

Yet, where would our brave troops be, at home and abroad, if they were deprived of the results of the skilled efforts made on their behalf by untiring engineers to insure that their camps are well placed and are sanitary; their water supplies good (if not always as ample as might be desired); and their communications—in the shape of roads and bridges—properly maintained?

Large numbers of highly-trained municipal, civil, and other engineers have gone to the front, or to the many camps up and down the country, there to give of the best of their technical knowledge and experience, in order that this may help to make the life of their comrades in arms safer, pleasanter, and more comfortable in every way.

How our soldiers are provided in certain cases with suitable supplies of drinking water is an interesting and important consideration. If a town supply be available the problem is, of course, a simple one, it merely being necessary to lay pipes of adequate section after making sure, by bacteriological examination, that the quality of the intended supply is above suspicion. Very frequently, however, a camp has to depend for its water supply on a river or a lake. In such a case the construction of filters is a first necessity. For this purpose barrels filled with filtering media are often employed. Over the bottom of one of a pair of barrels, connected at their lowest level by a short piece of pipe, a perforated metal plate is fixed, and resting on this, in evenly spaced layers one above the other, is charcoal, coarse sand, and gravel, respectively, the unfiltered water being poured or pumped on to the surface of the latter, which is a foot or so below the edge of the barrel. After percolating through the various layers the water, now considerably purified, passes through the connecting pipe to the second barrel, where, in its upward passage, it encounters successively layers of coarse sand, charcoal, and gravel, from the latter of which it emerges free from all matter in suspension, and ready to be drawn off at the top of the barrel for drinking or culinary purposes. It is assumed, of course, that the water did not originally contain any disease germs, which, naturally, cannot be removed by filtration, though subsequent boiling is generally efficacious as a germicidal process.

In camp the position of the supplies of water for men and horses is usually indicated by colored flags; thus, white means drinking water for men, and blue for horses, while doubtful water (suitable perhaps for washing purposes) is marked green, red indicating polluted water.

The locality of a camp is a matter for the General Staff to decide, but in choosing its exact position the engineer might well be consulted. He could indicate, with his knowledge of subsoils, the driest spot in the vicinity that was available. He would also see that the mechanical transport vehicles were parked in as good a place as could be found, and were not allotted some out-of-the-way marshy field, where there would be constant trouble occasioned at starting, and by the sinking in of vehicles. Good roads are a necessity to any camp, and here we may say what a boon has been the *pavé* of northern France and Belgium. In times of peace power-driven vehicles avoid these paved roads, with their shockingly uneven surfaces like the plague, all road maps marking *pavé* very clearly, so that it can easily be avoided. But in winter warfare these paved roads, built on this system from time immemorial, are a boon; for though they do have a decidedly bad effect, owing to their irregular contour, on the machinery of the heavy vehicles using them they enable progress to be made, whereas, but for them, transit would have to be conducted through a quagmire. This is often the case even now on roads leading up to the front and to large camps and stores depots, for the *pavé* is usually only wide enough for one vehicle, hence when troops or vehicles coming in an opposite direction are passed the unpaved side of the road has to be used—often with disastrous results. Engineers are therefore now at work on many such roads extending the *pavé*, so that two streams of traffic can pass without difficulty.—*The London Daily Telegraph.*

Electrification of Water by Splashing and Spraying

In the *Proceedings* of the Royal Society, Ser. 700, p. 531, J. J. Nolan endeavors to establish a connection between the charge produced on a sprayed liquid and the extent to which it has been broken up. The liquid used is distilled water, and two methods are described for breaking it up in contact with the air, (1) by splashing against an air-blast, (2) by spraying. In the first method drops are allowed to fall into a strong horizontal air current. Each drop is shattered by the blast into a number of varying size, and a rough sorting out is effected as the bigger drops are carried further aside by the blast. The drops chiefly used are the fine ones which enter a measuring vessel placed directly under the dropper, as these are fairly uniform in size. Variations in size can be obtained by altering the height of the dropper or the strength of the air-blast. In the second method an ordinary scent spray is used to form the drops. Measurements are made of the charge carried to the receiving vessel, the volume of water, and the number of drops which enter it (giving the mean size of the drops). It is found that the charge, E, per centimeter[3] of water increases with a decrease in the radius r of the drop. $E = k/r$ where k is a constant. This result is explained simply, on the assumption that the charge on the water is proportional to the area of new water surface created when the drops are formed. Both methods give good agreement in the value of the constant. The air drawn from the sprayer was examined to find how the negative charge is carried and it was found that the air contained a number of ions of both signs (excess of negative), ranging in mobility from the large ion found by Langevin to the ordinary atmospheric ion. It is probable that the excess of negative charge in the air is present mainly as small ions.

NEW BOOKS, ETC.

The Law of Carriers of Goods. By Ralph Merriam, of the Chicago Bar. Chicago: LaSalle Extension University, 1914. 8vo.; 180 pp.

The Act to Regulate Commerce. And Supplemental Acts. By Herbert C. Lust, of the Chicago Bar. Chicago: LaSalle Extension University, 1915. 8vo.; 141 pp.

In the first of these text-books the rather peculiar liability of the common carrier is made clear and, without attempting to trace exhaustively the maze of legal situations that emerge from this nucleus, the law and its elementary principles are closely detailed, and the student is instructed in the analysis and application of court decisions. In the second text the Act to Regulate Commerce, as amended, and sundry acts directly bearing upon the same subject, are presented in full, while the main body of the work expounds the terms and applications of this legislation and appends a series of test questions well adapted to disclose the knowledge—or display the ignorance—of the student. Both texts continue the expert and thorough work for which the course in interstate commerce and railway traffic must be ungrudgingly commended.

Field Practice. An Inspection Manual for Property Owners, Fire Departments and Inspection Offices. Boston: National Fire Protection Association, 1914. 16mo.; 100 pp.; illustrated. Price, $1.50.

Designed as an official handbook for all who are vitally interested in fire prevention, this convenient little volume deals with common fire hazards, their safeguarding, and the upkeep of protective devices and installations. It includes suggestions toward the safe handling of chemicals, paints and oils, and discusses spontaneous ignition, dust explosions, chimneys and flues, and dwelling house hazards. The second part of the work imparts much information as to automatic sprinkling installations and fire protection in general. The efficient carrying out of its simple instructions would mean a very appreciable diminution in fire loss.

Hancock's Applied Mechanics for Engineers. Revised and Rewritten by N. C. Riggs, Professor of Theoretical and Applied Mechanics in the School of Applied Science of the Carnegie Institute of Technology. New York: The Macmillan Company, 1915. 8vo.; 441 pp.; illustrated. Price, $2.40.

This is a text for students of the junior year, providing work for one semester, although the number of problems are in excess of this requirement. The title indicates, and the text realizes, the author's aim to make of problems in mechanics practical engineering work. The universal difficulty experienced by the student when he first endeavors to put theory into practice is met by following the development of each new principle by numerous applications. Into those applications much new material has been introduced. Particularly gratifying results in this direction are to be noted in the chapters on moment of inertia, center of gravity, work and energy, and friction and impact.

Out of Work. A Study of Unemployment. By Frances A. Kellor, editor of "Immigrants in America Review." New York: G. P. Putnam's Sons, 1915. 8vo.; 569 pp. Price, $1.50 net.

"Out of Work" thoroughly acquaints the reader with the present machinery of employment, both private and governmental, and pitilessly discloses its imperfections and its inadequacy. It exposes, also, the fallacies of complacency, which assume that a man can always get work of some kind; that snow shoveling and farm labor provide means of existence for the willing worker, and that unemployment is, in short, a moral rather than an industrial problem. There is no deliberate emotional appeal, but the bare statement of undeniable facts is sufficient to touch the heart and quicken the intelligence toward organized effort in the direction of bettering conditions. Much of the existing evil might be obviated by the adoption of methods indicated by the author, whose work delves to the primary causes of industrial distress and efficiently grapples with conditions, the evil of which can scarcely be exaggerated, and which the more favored individual but vaguely appreciates. The volume comprises a practical study, not an academical discussion, and bears internal evidence of first-hand knowledge, organized reasoning, and logical conclusions.

500 Plain Answers to Direct Questions on Steam, Hot Water, Vapor and Vacuum Heating. By Alfred G. King. New York: The Norman W. Henley Publishing Company, 1915. 8vo.; 214 pp.; illustrated. Price, $1.50.

All furnace heating systems and their problems are here dealt with in the form of questions and answers. When and why should a chimney be built round? When square? What is the thermostatic principle? What are the purposes of an equalizing pipe? What is a non-mechanical system of vacuum heating? These questions indicate the scope of the work, which distinctly tells the how and the why in terms that all may understand. It has value both as a text-book and as a reference book, and will prove particularly useful to any who are preparing to take examinations. It is not sparing of its diagrams, and many tables and formulas germane to the subject of heating are included.

A Doctor's Viewpoint. By John Bessner Huber, A.M., M.D. New York: Gazette Publishing Company, 1914. 12mo.; 164 pp.

The first paper of this collection, "A Twentieth Century Epic," is a really fine tribute to preventive medicine, with an appreciation of some of our medical martyrs and an intense sketch of the achievements of Gorgas in Panama. The other papers are more in the nature of commonsense talks on prevalent infirmities—little dishes of wit, wisdom, and folly, in which the wisdom generally manages to predominate to the distinct benefit of the reader.

The American Indian in the United States. Period 1850-1914. By Warren K. Moorehead, A.M. Andover, Mass.: The Andover Press, 1914. 4to.; 440 pp.; illustrated.

It is the author's belief that, in spite of the flood of popular literature relating to the Indian, he is still not properly understood. The work in hand seeks to present truthfully and comprehensively, so far as any study of human character may be comprehensive, the Indian of to-day, his traits, activities and tendencies, and the critical situation that confronts him. In the necessity of selecting the most significant facts from the wealth of available material, the author faced a difficult task, in which he has acquitted himself well. He skillfully blends the scientist's and the humanitarian's points of view. The result is an unusually accurate picture of the present-day Indian, with the influences both good and bad that have modified so materially his character and his outlook. The scandals of the reservations are bared, and a plea for justice is made. Good maps and illustrations add to the value of the work, which is avowedly but the first volume of a series by the same author, designed to treat adequately the American Indian of the present and the past.

Jesus and Politics. An Essay Towards an Ideal. By Harold B. Shepheard, M.A. New York: E. P. Dutton & Co., 1915. 12mo.; 145 pp. Price, $1 net.

It has been the author's aim to show the compatibility of Christianity and politics, the futility of politics without the church, and the sterility of the church without politics. There is much nobility of thought and a certain passionate sincerity in the volume, but it is unfortunate that the discourse is after all more in the nature of rhapsody than of convincingly-marshalled argument. This narrows its appeal to those already favorable to its tenets, and repels minds that are most in need of the leaven of its sentiment.

Scientific Feeding. By Mrs. Dora C. C. L. Roper, D.O. Oakland, Cal.: Published by the Author. 12mo.; 267 pp. Price, $1.05 net.

"Scientific Feeding" contains valuable suggestion and instruction, together with some unorthodox, even dubious, teaching. It embraces the classification and function of foods, and their preparation and combination. There are sample menus, with given caloric value, for the average adult and for the aged. Diet during pregnancy, the care and feeding of children, and breakfast, dinner, and supper menus, are discussed under food requirements. A "poor man's bill of fare" would call forth from most people the sympathetic exclamation, "Poor man indeed!" - and it seems as if more tasteful and substantial items might have been included, even under the lowest allowances. The bills are, however, varied and suggestive. A following section aims at the prevention and cure of disease, mainly by dietary correction. The author does not sufficiently recognize the fact that, although one man's meat may not literally be another's poison, the personal equation and acquired tastes play an important part in the result. The work should be read for inspiration and suggestion, rather than regarded as a perfected plan to be slavishly followed.

Essentials of English Speech and Literature. An Outline of the Origin and Growth of the Language, with Chapters on the Influence of the Bible, the Value of the Dictionary, and the Use of the Grammar in the Study of the English Tongue. By Frank H. Vizetelly, Litt.D., LL.D. New York: Funk & Wagnalls Company, 1915. 12mo.; 408 pp. Price, $1.50 net.

In an exceptionally well-arranged exposition, Dr. Vizetelly sets forth the origin of our language, its orthographical development, and the influences that have made it the plastic and efficient medium it is to-day. He specifically directs attention to mutations in orthography and syntax, bringing this investigation down to present usage. The conspectus includes chapters on the influence of the Bible on the drama and the periodical press; it explains the functions of the grammar and the dictionary, and emphasizes the benefits deriving from a study of both. The volume is of necessity selective rather than exhaustive, and it is in this selective process and in the general arrangement of his material that the author shows his keen judgment and his unobtrusive erudition. There is nothing more fascinating and at the same time more broadening than a study of the language and literature of a race, and the work in hand is entirely successful in conveying a great amount of information and instruction in a compact and appealing form.

The Practical Lumberman. Third Edition. By Bernard Brereton. Tacoma, Washington: Published by the Author. 16mo.; 256 pp.; illustrated. Price, $1.50.

"The Practical Lumberman" is a little book giving brief descriptions of the commercially most important woods of the Pacific Coast, with the color and grain of the manufactured product, the various ways of distinguishing merchantable grades, the shrinkage, the weight and strength, the many uses to which each wood is put, and other facts equally to the point. Short methods of figuring lumber are given. All the information of the little handbook is of value to both buyer and seller, and is so compactly presented that the volume will not overburden the ordinary coat pocket.

Electricity for the Farm. Light, Heat and Power by Inexpensive Methods from the Water Wheel or Farm Engine. By Frederick Irving Anderson. New York: The Macmillan Company, 1915. 12mo.; 265 pp.; illustrated. Price, $1.25.

In an Aladdin-like story of a farmer who returns one dark night from a vacation, to find his home and the outbuildings flooded with bright light at the touch of a button, we are shown the contrast between the old-style lighting that only serves to make gloom more impressive, and the wonders that may be accomplished at slight expense by employing the waste power of a water wheel. The volume conveys a practical working knowledge of electricity for the production of light, heat, and power. While the water wheel is put forward as an ideally cheap source of power, the windmill and the internal combustion engine are not slighted. The discussion includes such issues as the size of plant required, heating and cooking by electricity, transmission lines, and the operation of the plant. The instruction forestalls almost every possible need of the farmer in his application of electricity to the farm and in the operation of the simple machinery and accessories.

The Conquest of Mount Cook. And Other Climbs. An Account of Four Seasons' Mountaineering on the Southern Alps of New Zealand. By Freda Du Faur. New York: Charles Scribner's Sons, 1915. 8vo.; 250 pp.; illustrated. Price, $4.50 net.

The author's merry account of her earlier attempts at climbing is most entertaining reading, nor does she ever lapse into the pedantic. At the same time there is much of accurate observation and solid information in her work, which should at least commend it to the modest extent of her own wishes—that it may serve as an inspiration for some New Zealander with more material at his command to write more comprehensively of New Zealand mountaineering. Her introductory chapter is a *resume* of the climbing accomplished in the Mount Cook district between 1862 and 1909. The difficulty of obtaining details occasionally reduces this summary to a mere skeleton. Modest as the author's mode of narration is, one can but stand amazed at the physical endurance and pertinacity of will that enabled a representative of the frailer sex eventually to conquer the fastnesses of such a pile as Mount Cook. The numerous illustrations give clear, delightful glimpses of the serrate panorama of the district.

The Yellowstone National Park. Historical and Descriptive. By Hiram Martin Chittenden, Brigadier-General United States Army (Ret.). Cincinnati: Stewart & Kidd Company, 1915. 8vo.; 350 pp.; illustrated. Price, $1.50 net.

As the officer in charge of road construction, Brigadier-General Chittenden had an excellent opportunity of learning the Yellowstone in all its wonderful aspects. His work included the laying out of some four hundred miles of mountain roads; and the charm of mountain life, the lure of forest trails, and the surpassing grandeur which Nature has lavished upon this region, permeates to no small degree the pages of his volume. He sketches the early days of the *Mi tsi a da zi*, or *Pierre Jaune*, when Crow, Blackfoot and Bannock occupied the country, and the rival fur companies fought their historic battle, through the days of Coulter, Bridger, and other celebrated pioneers, with stories of the gold hunter and chronicles of the various exploratory expeditions. The boundaries and topography of the Park, its flora and fauna, its geological history and its natural marvels, are set forth in an orderly manner, and the administration of Park affairs of course occupies a position of prominence. A large folding map adds to the value and interest of the work. While its appeal to the general reader is undeniable, it also carries a wealth of detailed information not to be found in the books of the tourist-authors. An appendix tabulates the ranges and hills, the lakes, streams, waterfalls and geysers, and these are easily located upon the map by means of marginal references.

Bodily Changes in Pain, Hunger, Fear and Rage. An Account of Recent Researches into the Function of Emotional Excitement. By Walter B. Cannon. New York: D. Appleton & Co., 1915. 8vo.; 311 pp.; illustrated. Price, $2 net.

For several years the Harvard Physiological Laboratory has been engaged in a most interesting series of investigations. We are all familiar with the superficial phenomena of the primitive emotions—the facial contortions, the general muscular contractions. Almost as well-known an accompaniment of these states is the increase of available physical strength. Much deeper disturbances are revealed by Prof. Cannon and his collaborators. In his review of earlier European experiments and of his own recent investigations, the author clearly proves the drastic effects of pain, fear and rage upon the digestive system, to the extent of checking secretion of the gastric juice and interfering with the pancreatic secretion and the flow of bile. Thus all the natural processes for producing chemical change in the food may be perverted. Further, these researches disclose a remarkable increase of sugar in the blood. Diabetes and glycosuria are not infrequently traceable to an emotional origin. All these and other fundamental changes are discussed in their relation to increased muscular power and the fighting instinct. Modern warfare is condemned as inadequate to furnish a natural outlet for these emotional energies, and other ways of satisfying these instincts are suggested. The work is an incursion into a much-neglected field that promises to assume great importance in the future.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JUNE 12, 1915

Charles Allen Munn, President
Frederick Converse Beach, Secretary
Orson D. Munn, Treasurer
All at 233 Broadway, New York

Entered at the Post Office of New York, N. Y
As Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year	. . .	$5.00
Scientific American (est. 1845)	"	3.00
American Homes and Gardens	"	3.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, N. Y.

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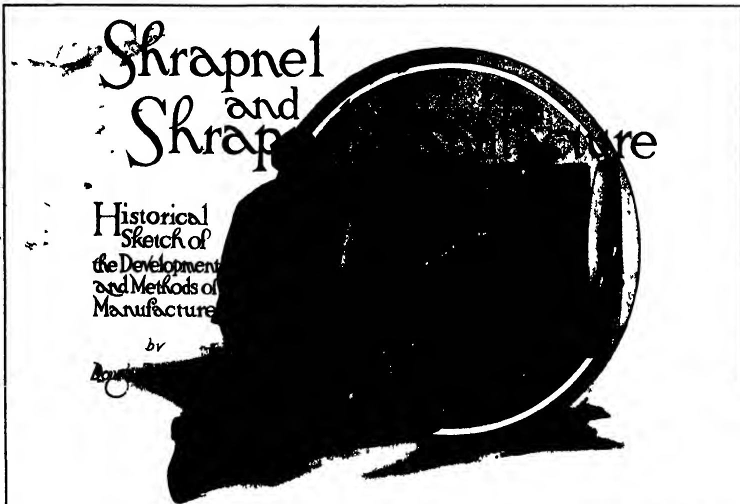
VOLUME LXXIX] NUMBER [illegible] NEW YORK, JUNE 19, 1915 [10 CENTS A COPY $5.00 A YEAR



IN naval coast defense and artillery operations several types of explosive shells are used the chief ones are the armor piercing shells made to pierce armor plate before exploding, shell exploded by means of a timing fuse, shells exploded by either a timing or percussion fuse, and shells exploded by percussion only Each different shell has some definite function to fulfil and is designed for that purpose For field or artillery operations, the shrapnel and lyddite are the two principal types used Of these shrapnel is the most prominent, because of its enormous destructive power and its interesting mechanical construction

The shrapnel shell was invented in 1784 by Lieut Henry Shrapnel, and was adopted by the British government in 1808 As is shown at *A* in Fig. 2, the first shell was spherical in shape and the powder or explosive charge was mixed with the bullets Although this type of shell was an improvement over the grape and canister previously used, its action was not altogether satisfactory, as the shell, on bursting, projected the bullets in all directions, and there was also a liability of premature explosion In order to overcome the defects mentioned, Col. Boxer (R. A.) separated the bullets from the bursting charge by a sheet iron diaphragm as shown at *B* in Fig 2 This shell was called a diaphragm shell to differentiate it from the first shell of this type.

In the shell made by Col. Boxer, the lead bullets were hardened by the addition of antimony and as the bursting charge was small, the shell was weakened by cutting four grooves extending from the fuse hole to the opposite side of the shell. Shells of spherical shape were first fired out of plain bored guns, and upon the advent of the rifled gun it was necessary to add a circular base, which was made of wood and covered with sheet iron or steel to take the rifling grooves. The first shrapnel shells were made of cast iron but a later development was to use toughened steel and elongate the body reducing it in diameter The diameter of the bullets was also reduced so that a greater number could be contained in a slightly smaller space The improved shrapnel was also capable of being more accurately directed

Shrapnel shells as used at the present time by the different governments vary slightly in construction and general contour as well as in the constituents entering into their different members As shown in Fig 1 a completed shrapnel comprises a brass case carrying a detonating primer and the explosive charge for propelling the projectile out of the bore of the gun The projectile itself comprises a forged shell that carries the lead bullets and bursting charge Screwed into the front end is the combination timing and percussion fuse which can be set so as to explode the shell at any desired point and from which the flame for exploding the bursting charge is conveyed through a powder timing train and a tube filled with powder pellets down through the diaphragm to the powder pocket.

Of these members of a shrapnel the shell and timing fuse present the most interesting features from a mechanical standpoint. The shell used by most governments is made from a forging, machined to the desired dimensions in hand and semi automatic turret lathes as well as in ordinary engine lathes. The fuse a complete description of which will be given later is an extremely accurate piece of mechanism and it is largely produced from screw machine parts, some of which however are forged previous to machining The brass cartridge case —the next member of importance—is drawn up from a brass blank by successive operations in drawing presses and is indented and headed Following this, several machining operations on the head and primer pocket are accomplished.

Shrapnel shells are made in two distinct types, one of which is known as the common shell and the other as the high explosive The common shell is a base charged shrapnel fitted with a combination fuse whereas the high explosive shell is fitted with a combination fuse and in addition with a high explosive head the head also bursting and flying into atoms upon impact The high explosive shell is not ruptured upon the explosion of the bursting charge in the base but the head is forced out and the bullets are shot out of the case with an increased velocity In the meantime the head continues in its flight and detonates on impact This type of shell is not used quite as extensively as the common shrapnel and for simplicity of description the common shrapnel shell alone will be taken up in the following

Reference to Fig 1 will show that as far as the construction of the shrapnel shell and case is concerned there is very little difference in those employed by the various governments Starting with the case it will be seen that these are almost identical except for length and the arrangement of the head for carrying the detonating primer There is a marked similarity in this respect between the Russian British and German and between the American and French The form of the explosive charge held in the brass case differs in almost every instance but without any exception smokeless powder in some form or other is used In the American shell nitro-cellulose powder composed of multi perforated cylindrical grains each 0.35 inch long and 0.195 inch diameter are used In the Russian case smokeless powder of crystalline structure is used In the German smokeless (nitro-cellulose) powder in long sticks and arranged in bundles is held in the case The French use stick smokeless powder ½ millimeter (0.0195 inch) thick by 12.69 millimeters (½ inch) wide Two lengths or rows of this powder are arranged in the case The British use a smokeless powder of crystalline structure somewhat similar to the Russian but in

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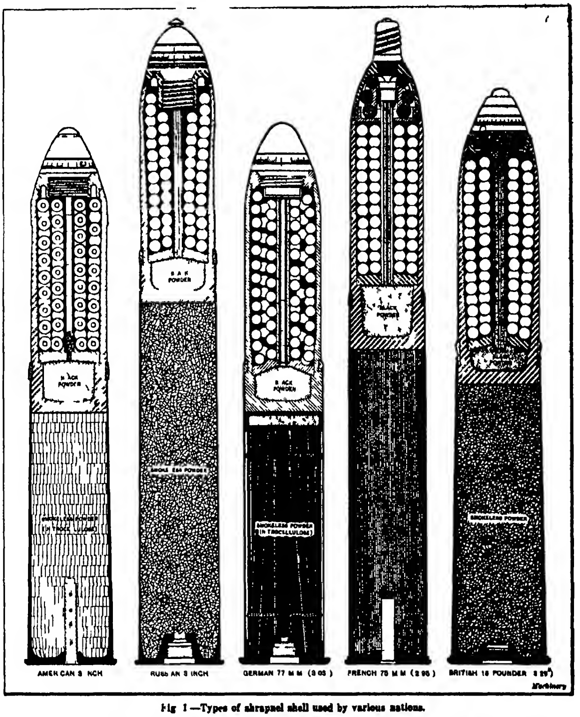


Fig 1—Types of shrapnel shell used by various nations.

some cases cordite has also been used although of late this type of powder has not been quite as commonly employed

The detonating agents or primer held in the head of the case varies in almost every type of shrapnel Practically all primers are provided with safety heads so that the shrapnel can be handled without danger of premature explosion The object of course of the detonating agent or primer is to send off the explosive charge in the shell for propelling the shrapnel out of the field gun

The shell itself as previously mentioned is made either from a forging or from bar stock Forgings however are used to a greater extent than bar stock because the forged shell is more homogeneous in its structure than the bar stock shell and piping a serious objection in the bar stock shell—is entirely eliminated

The shells used by the British Russian and German governments are made almost exclusively from forgings whereas those used by the French and American are made both from forgings and bar stock When the French shell is made from bar stock an auxiliary base is screwed in to eliminate any danger of piping Near the base of all shells is a groove in which a bronze or copper band is hydraulically shrunk This is afterward machined to the desired shape and takes the rifling grooves in the gun so as to rotate the shell when it is being expelled The body of the shell itself is slightly smaller than the bore in the gun and the rifling band, of course is larger and is compressed into the rifling grooves thus rotating the projectile and keeping it in a straight line laterally during flight The bursting charge which in practically all cases is common black powder is carried in the base of the shell and is usually inclosed in a tin cup Located above this is the diaphragm which is used for carrying the lead bullets out of the shell when the bursting charge explodes and distributes them in a fan shape In most shells upon exploding the nose blown out, stripping the threads that hold the members together It will therefore be seen that in the explosion the entire fuse fuse base tube diaphragm and bullets are all ejected the shell itself acting as a secondary cannon in the air

The range of a 3 inch shrapnel shell is about 6 500 yards, and the muzzle velocity of the quick firing field gun ranges from 1 700 on the American to 1 930 feet per second on the Russian The duration of flight ranges from 21 to 25 seconds When the bullets are blown out of the shell by the bursting charge they are given an increased velocity of from 250 to 300 feet per second The velocity of the shrapnel at 6,500 yards is about 724 feet per second The number of lead bullets carried in the 3 inch shrapnel shells ranges from 210 to 360 In all cases the lead bullets are about ½ inch in diameter weigh approximately 167 grains and are kept from moving in the shell by resin or other smoke-producing matrix

The matrix put in with the lead bullets, in addition to keeping them from rattling is also used as a tracer It is of importance in firing shrapnel that the position of the explosion be plainly seen With large shells this is not difficult, but with shrapnel for field guns at long range certain conditions of the atmosphere make it difficult to see when the shell actually bursts. Various mixtures are used to overcome this difficulty In some cases fine grained black powder is compressed in with the bullets in order to give the desired effect. In the German shrapnel a mixture of red amorphous phosphorus and fine grained powder which produces a dense white cloud of smoke is used, and in the Russian, a mixture of magnesium antimony sulphide is used.

The first fuses used in field ammunition were short iron or copper tubes filled with a slow burning composition These were screwed into a fuse hole provided in the shell, but there was no means for regulating the time of burning Later—about the end of the seventeenth century—the fuse case was made of paper or wood so that by drilling a hole through into the composition the fuse could be made to burn for approximately the desired length of time before exploding the shell or the fuse could be cut to the correct length to accomplish the same purpose

For a considerable time all attempts to produce a percussion fuse were unsuccessful Upon the discovery of fulminate of mercury in 1799, the chief requirement of a percussion fuse was obtained. About fifty years elapsed, however before a satisfactory fuse was made. The first percussion fuse was known as the Pettman fuse, and comprised a roughened ball covered with detonating composition that was released upon the discharge of the gun When the shell hit the desired object, the ball struck against the inner walls of the fuse, exploded the composition and powder charge, thus bursting the shell. There are at the present time three principal types of fuses in use: First, those depending on gas pressure in the gun setting the pellet of the fuse free—this is a base fuse; second, those relying on the shock of discharge or the rotation of the shell to set the pellet free—used in nose and base fuses; third, those depending on impact.

In shrapnel shells advantage is taken of two types of fuses, one of which is the combination timing and percussion fuse used on common shrapnel, and the other the combination timing and percussion fuse of the high-explosive type used on high-explosive shrapnel. These types of fuses are again sub-divided, but only in the manner of construction. The most common fuse is that known as the combination timing and percussion fuse of the double-banked type. This is used in practically all shrapnel fuses except the French. The advantage

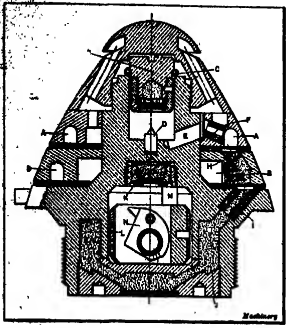


Fig. 3.—American type of confined timing and percussion fuse used on shrapnel shells.

of the double ring of composition shown at *A* and *B* in Fig. 3 is to give a greater length of composition and more accurate burning. Triple-banked and quadruple-banked fuses on the same principle have been designed, but at the present time have not been introduced.

The manner in which the combination timing and percussion fuse is regulated to discharge the bursting charge in the shrapnel shell is interesting and involves extremely difficult mathematical calculations. Before going into the method of setting the fuse, it would probably be advisable to describe briefly just how the fuse operates. As an example of the double-banked fuse, Fig. 3 shows that adopted by the American Government. The following description applies to this type of fuse.

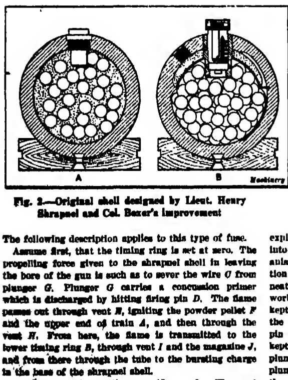


Fig. 2.—Original shell designed by Lieut. Henry Shrapnel and Col. Boxer's improvement

Assume first, that the timing ring is set at zero. The propelling force given to the shrapnel shell in leaving the bore of the gun is such as to sever the wire *C* from plunger *G*. Plunger *G* carries a concussion primer which is discharged by hitting firing pin *D*. The flame passes out through vent *E*, igniting the powder pellet *F* and the upper end of train *A*, and then through the vent *H*. From here, the flame is transmitted to the lower timing ring *B*, through vent *I* and the magazine *J*, and from there through the tube to the bursting charge in the base of the shrapnel shell.

Assume any other setting, say 12 seconds. The vent *H* is now changed in position with respect to vent *E* leading to the upper timing train, and the vent *I* leading to the powder magazine *J* is also changed. The flame, therefore, now passes through vent *E* and burns along the upper train *A* in a counterclockwise direction until the vent *H* is reached. It then passes down to the beginning of the timing train and burns back in a clockwise direction to the position of vent *I*, from which it is transmitted by the pellet of compressed powder in this vent to the powder magazine *J*. It should be understood that the annular grooves in the lower face of each timing train do not form complete circles, a solid portion being left between the grooves in the ends of each. This solid portion is used to obtain a setting at which the fuse cannot be exploded and is known as the "safety point." As shown in Fig. 6, it is marked *S* on the adjustable timing ring.

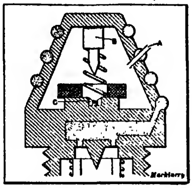


Fig. 5.—French type of combination timing and percussion fuse.

The timing fuse shown in Fig. 3 is of the combination timing and percussion type, and if the wire *C* fails to release percussion plunger *G* in Fig. 3, the shell is exploded by means of a percussion fuse which comes into use when the shell strikes. The percussive mechanism consists of a primer *K* held in an inverted position in the center of the fuse body by a cup located beneath the percussive primer. Percussion plunger *L* works in a recess in the base of the fuse body and is kept at the bottom of the recess away from contact with the primer by a light spring in plunger *M*. The firing pin *N* is mounted on a fulcrumed pin, and is normally kept in the vertical position by means of two side spring plungers. When the shell strikes, the impact causes the plunger to snap up against the primer after compressing the spring in pin *M*. This causes the firing of the primer *K* and the explosive charge passes out through a hole in the percussion plunger chamber, not shown, to the magazine *J* and from there down to the powder in the base of the shell.

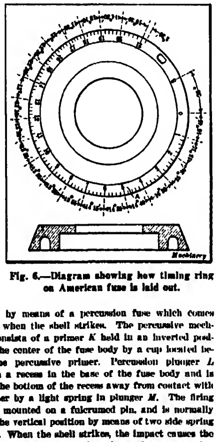


Fig. 6.—Diagram showing how timing ring on American fuse is laid out.

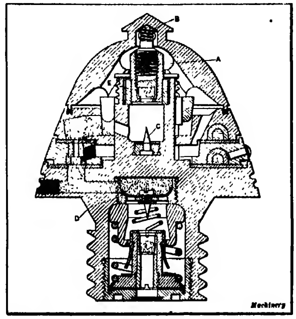


Fig. 4.—Russian type of combination timing and percussion fuse used on shrapnel shells.

The Russian fuse shown in Fig. 4 differs only in a few minor details from the American fuse the chief difference being in the arrangement of the percussive mechanism. The percussive plunger for the timing arrangement is kept up from the firing pin by means of a spring bushing *E* surrounding the body of the plunger. This bushing is expanded by the plunger which is forced through it due to the force of the shrapnel in leaving the bore of the gun. The spring *B* in the head of the fuse assists the plunger in expanding bushing *E* and in dropping down onto the firing pin *C*. The flame from the exploded primer then travels down to the powder in the shell in practically the same way that it does in the American fuse, except that the magazine chamber is located at *D* and explodes through the impact fuse chamber. The percussive arrangement for setting the shell off by impact is slightly different from that in the American fuse, in that the primer and firing pin are held apart by means of springs, the inertia of which is overcome when the shell strikes an object.

With the exception of a few minor details, the timing fuses used in American, Russian, British, German, Japanese, etc., shrapnel shells are the same. The French timing fuse, however, as shown by the diagram Fig. 5, operates on an entirely different principle. In this fuse the firing for the timing train is contained in a sealed tube of pure tin and is wound spirally around the head of the fuse. Inside of the head is the ignition arrangement. To set the timing part of this fuse, it is placed in a fuse-setting machine attached to the field gun, and by forcing down a handle on this device, a piercing point is thrust through the outer cap of the fuse, penetrating to the interior space of the head as shown at *A*. Upon the discharge of the shell from the gun, the gas pressure forces firing pin *B* back, hitting the percussive primer *C*. This causes a flame which passes out through the opening previously punched at *A* and ignites the "rope" powder fuse which is wound around the head of the fuse body. This type of fuse is also provided with a fuse which sets off the shell by impact should the timing fuse fail to work. The head of the fuse is covered with a cap with holes for the piercing point, and the whole cap can be shifted around for a short distance and set by the corrector scale marked on the body, as shown in Fig. 1. A projection on the cap engages a recess in the fuse-setting machine and provides for this movement, the machine previously being set to punch the hole.

The accuracy with which a shrapnel can be exploded in the air at any desired point is remarkable, considering the number of variable quantities that enter into the construction of the timing fuse and powder train,

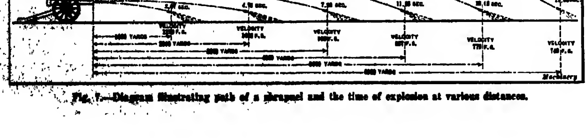


Fig. 7.—Diagram illustrating path of a shrapnel and the time of explosion at various distances.

etc. The calculations necessary for finding the correct setting on the timing ring involve the use of higher mathematics and are consequently not within the scope of this article. In the following, however, will be given a brief explanation of how a fuse is set to explode the shrapnel at a certain predetermined point.

Referring to Fig. 6, the timing ring used on the American fuse is shown. Here it will be seen that the ring is provided with twenty-one graduations corresponding to twenty-one seconds in the duration of flight of the projectile. It will also be noticed that the spacing of the graduations differs. For instance, S to zero, or safety to zero, occupies 26 degrees. This, as previously mentioned, is required so that the ungrooved surfaces of the timing rings can be swung around far enough to bring them in line with the vents for firing. From zero to 1 is greater than from 1 to 2. The reason for this is also in the relation of the vents. From 3 to 4 will be seen another variation. This takes into consideration the positions of the lower timing train and the trajectory of the flying missile. From 6 seconds around to 18 is practically a constant drop, taking into consideration the decrease of velocity, and from 18 on, the graduations begin to increase for two reasons: the decrease in the velocity of the missile and the action of gravity.

Diagram Fig. 7 shows in an interesting manner just how a shrapnel is fired. The range is approximately obtained by panoramic sights or other means, and a test shell fired, the point of explosion noted and the necessary corrections made. A table which has been worked out for different distances is then used. In Fig. 7 the diagram shown pertains to the American quick-firing field gun having a muzzle velocity of 1,700 feet per second and the American shrapnel of 3-inch size. It will be noted that at 3,000 yards the terminal velocity of the shrapnel is 1,068 feet per second and the time of flight for the projectile 4.75 seconds. In other words, the timing train to explode the shrapnel at this point would be set at A in Fig. 6. The range of a 3-inch American shrapnel is 6,500 yards and at this point the terminal velocity is approximately 724 feet per second, the time of flight 21.92 seconds. The shrapnel, when exploded, shoots out the bullets at an increased velocity of from 200 to 300 feet per second, covering an area of about 250 by 30 yards, half the bullets falling on the first 50 yards of the beaten zone.

In manufacturing shrapnel shells a test shell is taken from every 120 and is actually fired out of a quick-firing gun into a bank of sand. If the contour of the shell in the neighborhood of the powder pocket is expanded during this test, the shell is discarded because of the liability of tearing out the rifling grooves in the gun.

Star Clusters

Of all the telescopic objects in the sky none are more beautiful or more fascinating than the condensed globular star clusters. Their bewildering complexity renders them unsuitable for direct study at the telescope, but photography has now brought them within the range of systematic investigation. The technical problem which they present is by no means easy, and demands high resolving power for success.

Considerable attention was given to the star clusters by Sir John Herschel, whose attempts to depict them by hand met naturally with small success. Certain curious irregularities which he believed to exist in the distribution of the stars may be attributed to a purely subjective origin, or they may be accounted for by the absorptive influence of external dark nebulous masses. No great importance is now attached to them, and in the main the stars may be considered as distributed with radial symmetry. But one curious feature noticed by Sir John Herschel has been confirmed by later study. The stars in a cluster tend to divide into two classes of magnitude, a brighter and a fainter, separated by a distinct interval. Can this be a visible division of stars presumably at the same distance and of nearly equal age into the two classes of giant and dwarf stars inferred by Hertzsprung and H. N. Russell?

About 20 years ago Prof. S. I. Bailey, at that time at Arequipa, devoted considerable study to photographs of the chief globular clusters. His work proceeded on two lines. On one hand he made systematic counts of the stars recorded, thus laying the foundation for statistical investigations of their arrangement in space. And on the other he investigated the magnitudes of the stars, and was thus led to the remarkable discovery that several clusters contain a high proportion of variable stars, a ratio of 1 to 7 in the extreme case of M3. His detailed results for the clusters ω Centauri and M3 have been published in two beautiful memoirs. The type of variation is of a distinct character, though a few isolated examples have been found elsewhere in the sky, with a period of about 12 hours and a rapid rise to maximum. In the case of M3 the variation is singularly true to one type, the range between maximum and minimum being two photographic magnitudes. Some clusters, notably M13, are almost entirely devoid of such variables; where they do occur they are apparently confined to the stars of the brighter order of magnitude.

The question of the distribution of stars in clusters was discussed by Prof. E. C. Pickering. Using counts on the clusters ω Centauri, 47 Tucanæ and M13 (Herculis), he formed the important conclusions: (1) that the law of distribution is essentially the same for different clusters, (2) that the bright stars and the faint stars of a cluster obey the same law. He represented graphically the curve of apparent (projected) density for different distances from the center, and attempted without success to reproduce it by assuming laws of the form $1-r^2$ and $(1-r)^n$ for the density in space. The latter form was also tested by Mr. W. E. Plummer with much the same result on an extensive series of measures of the stars in M13.

The next important contribution to the subject is due to H. v. Zeipel, who measured the positions of the stars in M3 (Can. Ven.). By adapting the solution of a certain integral equation studied by Abel he showed how the law of distribution in space may be deduced numerically from the observed distribution as it is seen in projection. Later he compared the law of density in space arrived at in this way with that which obtains in a gravitating spherical mass of gas in isothermal equilibrium. The result represents the density of the cluster satisfactorily near the center, but in the outer regions the cluster is less dense than the theory requires.

The physical conception thus introduced suggested other possibilities. A sphere of gas in adiabatic, instead of isothermal, equilibrium might be chosen as the standard of comparison. A series of states exists, depending on the constant ratio γ of the specific heats of the gas, which have been extensively studied by Lord Kelvin and others. Emden's "Gaskugeln" is a work dealing exhaustively with the subject. In general, the law of density cannot be expressed in finite terms. But there are exceptional cases in which the differential equation possesses a very simple solution. One of these, discovered by Schuster, corresponds to the value $\gamma=1.2$. Here the law expressing the density at the distance r from the center takes the form:

$$3a^2N/4\pi(a^2+r^2)^{5/2},$$

where N is the total mass or number of stars. This is finite, although the distribution extends to infinity. If a finite boundary be expected it is impossible to fix one by the counts, and attempts to do so have been proved illusory by the occurrence of characteristic variable stars beyond the supposed limit. However this may be, a comparison of the law with Bailey's counts of the ω Centauri cluster showed immediately an agreement within the limits within which radial symmetry is observed. I next compared the law with Pickering's curve of the projected densities, based on the clusters ω Centauri, M13 and 47 Tucanæ (bright and faint stars treated separately). The accordance was again excellent, and left little doubt that the law represented much more than a mere formula of interpolation. When, however, v. Zeipel's counts of M3 were examined, the outer region was found to conform with the law, while the inner revealed a higher density than was to be expected. As v. Zeipel had, on the other hand, succeeded in representing the central distribution by the isothermal law, it was suggested that the true standard of comparison was a central isothermal core surrounded by an adiabatic envelope, a composite state of equilibrium actually contemplated by writers in the thermodynamics of the subject. Afterwards, by the use of similar methods, Prof. Strömgren proved that M5 (Serpentis) possesses a structure which, whatever the cause, is identical with that of M3. V. Zeipel remarked that the excessive central condensation was more marked among the bright than among the faint stars.

The problem has again been discussed by v. Zeipel in an elaborate memoir, using in this instance counts of the stars in M2 (Aquarii), M3, M13 and M15 (Pegasi). He first finds solutions corresponding to these values of γ:

(M2) 1.200, (M3) 1.156, (M13) 1.183, (M15) 1.179

Thus M2 conforms with the same simple law, which I had found to hold so perfectly for ω Centauri. On the other hand, M3 is again seen to depart from it, and even with the new value of γ the representation is far from good. The law of density here contemplated is a solution of the equation:

$$\frac{d^2(r\rho^{\gamma-1})}{dr^2} + r\rho = 0,$$

and satisfies a physical condition in being regular at the center. The general solution, however, possesses a singularity at this point, and contains an additional arbitrary constant. Thus the particular law given above is only a special case of the general solution for $\gamma=1.2$, which, as v. Zeipel shows, can be expressed in elliptic functions. Accordingly, he abandons the central condition, and introduces the additional constant which is to be determined, together with γ, for each case. With this modification of the theory the values of γ became:

(M2) 1.194, (M3) 1.198, (M13) 1.203, (M15) 1.197,

so that within the limits of uncertainty in every case the distribution of stars is consistent with a solution of the above differential equation when γ is assigned the value 1.2.

The analogy between the distribution of stars in a condensed cluster and the density in a spherical mass of gas of a particular type in adiabatic equilibrium thus seems to be fairly established. Even if it be supposed that the cluster is the outcome of an original nebula the question still remains why the distribution of matter should persist long after its condition has completely changed, or why the arrangement should resemble what might be expected of certain vapors (e. g., chloroform). The answer given by v. Zeipel on the basis of a strict mathematical analysis is that this is in conformity with a kinetic theory which applies to an aggregate containing a high proportion of Keplerian binaries. This may be a bold application of the law of large numbers, but it is certainly an interesting conception. Since there is every reason to believe that all short period variables are binary systems the observed occurrences of these in clusters lends support to the view, though they can only represent the exceptionally close systems. The investigations here described refer exclusively to the highly condensed clusters. But there exist also clusters showing states of concentration in varying degree until probably all visible trace of organic connection is lost. In Strömgren's view the whole series represents an order of evolution by which the dense clusters grow out of more scattered forms. Whether the results will throw light on the wider problems of the structure of the sideral universe seems doubtful in view of certain conclusions drawn by Poincaré, Jeans and Eddington as to the relevance of the kinetic theory. But taken by themselves they present questions of the highest interest which are likely to repay further study.—H. C. Plummer in *Nature*.

Fixation of Atmospheric Nitrogen

Experiments have been conducted by I. A. Stahler and J. J. Elbert, as reported in the *Ber. Deut. Chem. Ges.*, 46, p. 2060, for obtaining boron nitride; and as most naturally occurring compounds of boron are combined with oxygen, the first step was to ascertain the best methods for their reduction, followed by the combination of the boron obtained with nitrogen. The reduction of boron trioxide by carbon begins to take place at 1,200 degrees; in the presence of nitrogen, calcium borate (borocalcite) undergoes reduction at 1,280 degrees, reaction probably taking place according to the equation: $CaB_4O_7 + 8C + 3N_2 = 4BN + CaCN_2 + 7CO$.

The electrolysis of molten borax gave yields of boron to the extent of 12.1 per cent. Carbon electrodes were first used, but they broke off repeatedly at the surface of the fusion; iron electrodes lasted longer, but they also broke off after a time. Attempts to reduce boron trioxide by means of calcium carbide at 1,625 degrees made it probable that the product of reaction was calcium boride, which has previously been prepared by Moissan.

Before carrying out further experiments on the production of boron nitride it was necessary to determine its stability; it was found that decomposition with evolution of nitrogen only commenced to take place at 2,450 degrees; this temperature of decomposition holds only in the presence of carbon, since the boron nitride was contained in a graphite crucible.

The next experiments were confined to mixtures of carbon with either boron trioxide or borocalcite. These were heated to different temperatures in an atmosphere of nitrogen under different pressures, a special electrical furnace having been constructed in which reactions could be carried out at pressures up to 500 kilogrammes per square centimeter, and at temperatures up to 2,500 degrees. With mixtures of boron trioxide and carbon and nitrogen at atmospheric pressure, the best yield, 26-28 per cent of boron nitride, is obtained between 1,600 degrees and 1,700 degrees. With increasing pressure the yield increases, more than 85 per cent of boron nitride being obtained at a pressure of 70 kilogrammes per square centimeter and a temperature of 1,600 deg. When the boron trioxide is replaced by borocalcite, a nearly theoretical yield of boron nitride, according to the equation given above, is obtained when the temperature is maintained at 1,350 degrees for 30 minutes and 1,400 degrees in 15 minutes; increase in pressure of the nitrogen has no effect on the yield. At normal pressures the amount of nitrogen absorbed per gramme of boron is much greater with borocalcite than with boron trioxide; only at very high pressures are better results obtained with boron trioxide than with borocalcite.

The Chemical Industries of Germany—I*

An Historical Review of Processes and Conditions

By Prof. Percy F. Frankland, F.R.S.

It is remarkable that the Royal House of Prussia has during many centuries been associated in one way or another with chemical enterprises of various kinds. Thus already the second ruler of the country, the Markgraf John (1608-1619) was actually surnamed "the Alchemist" in consequence of the zeal with which during many years he pursued his investigations on the transmutation of metals, while a number of his successors exhibited great interest in the same problem—the manufacture of gold—which has never failed to fascinate the needy princes—and what princes are *not* needy?—of all ages and all nations.

The Great Elector (1640-1688), who did so much to advance the power of Prussia, was a patron of chemistry, which was just then beginning to emerge, as an experimental science from the obscurantism of alchemy. He provided the celebrated Kunkel with a laboratory and glass furnaces on an island in his park at Potsdam, and it was there then in 1678 Kunkel made the discovery of ruby glass, produced by means of traces of gold, and which is still an unsurpassed method of coloring glass for ornamental purposes. Kunkel also rediscovered phosphorus, which has previously, in 1669, been obtained by the alchemist Brand of Hamburg, who had quite accidentally produced it in the course of his attempts to extract the Philosopher's Stone out of urine.

But while the discovery of yellow phosphorus is thus of German origin, its production on an industrial scale was, until twenty years ago, only carried on in England and France. In 1892, the manufacture of phosphorus by electrothermic means was introduced into Germany by the Chem. Fab. Griesheim-Elektron at Frankfort.[1] Red phosphorus was discovered by Schrötter, an Austrian chemist, in 1848, and was adapted for safety-matches by the German Böttger in the same year. His invention was first taken up in Sweden, and was not adopted until ten years later in Germany.

The match industry has assumed its largest dimensions in Germany. Thus the German annual production in 1912 was $23,000,000.[2] The value of all matches (British and foreign) consumed in Great Britain in 1910 is estimated at $6,468,750—about nine matches per day per head. Messrs. Bryant and May's (by far the largest English concern) turned out 1,152,000,000 boxes in 1907. This represents about one half the British output. In 1907 the total value of British production was $3,875,000, of which $380,000 worth was exported.[3] The British export of matches is diminishing. It is worthy of note that Japan in 1901 exported matches to the value of $6,000,000.

PORCELAIN.

Another great German industry owes its origin to alchemistic studies made by Böttcher in the reign following that of the great Elector, namely, that of Frederick III. (1688-1713), first King of Prussia. Having succeeded in making gold before witnesses, Böttcher was seized by order of the Elector of Saxony and was "interned" at Dresden, where, although he did not succeed in making the much-desired gold, he founded along with the physicist Tschirnhaus, the celebrated Dresden porcelain industry.

The astute Frederick the Great (1740-1786) was anxious to manufacture the Dresden ware at Berlin and to this end commissioned his court apothecary, Johann Heinrich Pott, to institute investigations. These attempts were, however, all unsuccessful.

The great Frederick placed much faith in secret agents and it was by means of spies that he succeeded in discovering the secrets of the Dresden porcelain manufacture, for at his instigation an enterprising merchant, bearing the name of Gotzkowski, with the assistance of a Saxon workman, brought the secrets of the Dresden process to Berlin and established a porcelain factory in the Leipziger Strasse, which still remains the warehouse for the Berlin porcelain goods. But Frederick later stopped the pecuniary assistance with which the factory had been subsidized, and Gotzkowski was forced to sell the concern of Frederick for about $150,000, and so was established the celebrated Berlin Royal Porcelain Factory, among the products of which are the well-known crucibles and evaporating basins. The flourishing state of the German porcelain and pottery manufacture is attested by the fact that during the past twenty-five years the number of works has increased from 228 to 359, and the number of workpeople employed from 37,000 to 66,000. In 1912 the German export of china, earthen and stoneware were valued at upwards of $17,500,000.

GLASS.

Even still more important is Germany's glass manufacture, for which she has long been pre-eminent. The annual export in recent years has been over $35,000,000.

CYANIDE INDUSTRY.

In the early eighteenth century an accidental discovery was made by Diesbach, a Berlin color-maker, which has proved of great industrial importance. Diesbach was preparing what is known as Florentine lake, a red pigment obtained by precipitating a solution containing cochineal extract and an iron salt with caustic potash. It so happened, however, that the potash used by Diesbach had been in contact with bone-oil containing some cyanide, and the result was that, instead of the result he anticipated, a magnificent blue coloring matter was obtained. This substance, which is still known as Berlin or Prussian blue, was the first cyanogen compound to be discovered.

The cyanogen compounds have played a most conspicuous part in the development of organic chemistry, and every source of cyanogen has been exploited for obtaining them. In recent years the demand has increased enormously owing to the employment of sodium and potassium cyanides in the extraction of gold. To meet this demand a number of synthetical methods for their preparation have been super-added.

Germany's annual production of cyanides is estimated at 10,000 tons, valued at $3,250,000, or about half of the world's production.

BEET-SUGAR INDUSTRY.

Another industry also had its beginnings in the eighteenth century during the reign of the Great Frederick, and was the outcome of the laborious researches of Marggraf (born in Berlin in 1709, and a pupil of Stahl) on the occurrence of sugar in the vegetable kingdom. Of the numerous plants investigated from this point of view he found that the beetroot (*Beta vulgaris*) contained the largest proportion of saccharine material and that the sweet-tasting substance was identical with that present in the tropical sugar cane (*Saccharum officinarum*).

It was not, however, until some fifty years later that the observations of Marggraf led to the first beet-sugar factory in the hands of Franz Karl Archard, who was subsidized in this venture by the Prussian King, Frederick William III. (reign 1779-1840), who was also the founder of the University of Berlin.[4]

The beet-sugar industry had to contend with strenuous competition by the cane-sugar manufacturers. The industry was, however, greatly promoted when, in 1806, Napoleon issued his famous edict closing the European ports to British goods. The vast extent of this industry can be gathered from the following figures:

Total sugar crop for 1912-13: Cane sugar, 9,211,755 tons; beet sugar, European (one third German), 8,310,000 tons; beet sugar, United States, 624,064 tons; total, 18,145,819 tons.

The sugar industry should give us food for serious reflection when we consider the following facts: United Kingdom spends annually $115,000,000 on 1,700,000 tons imported sugar. Germany produces $180,000,000 worth of beet sugar on 1,300,000 acres. France produces $65,000,000 on 570,000 acres; all continental countries together produce $580,000,000 on 6,000,000 acres.[5] In the United Kingdom there is only one small experimental beet-sugar factory in existence. The beet-sugar industry is of particular interest in connection with the present European crisis, inasmuch as it is a most notable example of an industry which largely owes its successful inception to a state of war which disturbed the previously established order of things in the matter of sugar supply.

In this country (Great Britain) agriculture is well known to be productive of a conservative frame of mind, but that it is not so in Germany is well illustrated by the extraordinary progress which has been made in the cultivation of the sugar beet under the guidance of systematic scientific research. Thus, in 1840, 100 kilogrammes of beet gave 5.9 kilogrammes of sugar; in 1850, 7.3; in 1870, 8.4; in 1890, 12.5; and in 1910, 15.8. In 1871 the mean production of beet per hectare[6] was 246 quintals,[7] and in 1910, 300 quintals. In 1867 the consumption of coal for 100 kilogrammes of beet was 35 kilogrammes; in 1877, 24; in 1890, 10, and in 1900, 7. Further economy in coal has been affected by means of the Kestener concentrator.[8]

SULPHURIC ACID, SODA AND BLEACHING POWDER

Sulphuric acid was discovered by the German alchemist Basil Valentine in the fifteenth century. The production of this fundamental acid, however, on any considerable scale took its origin in Birmingham, where Dr. Roebuck in 1746 introduced the classical leaden chamber process. At the beginning of the nineteenth century it became an industry of great importance, more especially in England, because of this acid being required for the manufacture of carbonate of soda by the Le Blanc process.

The manufacture of Le Blanc soda was taken up in England in 1814, especially in connection with soap-making, and it was in England that this manufacture assumed the largest proportions. The enormous advances made in this manufacture during the past century may be gathered from the fact that the price of carbonate of soda in 1818 was about $210 per ton, while to-day it is only about one tenth of that amount. One of the determining factors which made England the principal home of soda manufacture was the great development of the English cotton industry during the nineteenth century.

During a large part of the last century England manufactured Le Blanc soda, sulphuric acid and bleaching powder[9] for most of the world. But during the latter half of the century the rival ammonia soda process made its appearance. The original discovery of the reaction on which it depends—it was first patented in England by Dyar and Hemming in 1838—is ascribed to several different persons, but the process was first made an industrial success in Belgium by M. Ernest Solvay. The Couillet works were founded with a capital of about $30,000 in 1863; the numerous affiliated works are now to be found in Belgium, England (Brunner, Mond and Company), Germany, France, Italy, Spain, Austria-Hungary, Russia and North America. They employ 35,000 persons. During the fifty years the price of soda had been reduced from $80 to $20 per ton. The displacement of Le Blanc soda by ammonia-soda involved the introduction of new methods of chlorine manufacture. After numerous abortive attempts in various directions, the successful production of electrolytic chlorine has been achieved, and about half of the bleaching powder in the world is now made by this means.

Electrolytic chlorine is now often converted into liquid chlorine (12 cents a kilogramme), of which large quantities are used at Stassfurth for the annual preparation of 500,000 kilogrammes of bromide, and the Badische Aniline und Soda Fabrik used in 1900 more than 1,000,000 kilogrammes for the preparation of chloracetic acid employed in the manufacture of synthetic indigo.

In the manufacture of sulphuric acid, again, the old-fashioned English or leaden chamber process has not been allowed to remain unchallenged, for since the beginning of the present century it has had to meet the competition of the so-called contact process. This is based on a long known reaction,[10] which, however, remained almost unutilized until the meticulous industry of German chemists and the courageous enterprise of German manufactures developed it into a commercially successful process, which was elaborated in the works of the Badische Aniline und Soda Fabrik.

The ammonia-soda and the contact sulphuric acid[11] processes, although carried out in England, have been largely instrumental in making other countries, more especially Germany and the United States, independent of the English production of these all-important chemicals.

* A paper read before the Birmingham section of the Society of Chemical Industry, on March 4th, 1915.

[1] The author has much pleasure in acknowledging the assistance he has received from the valuable compilation by Prof. Lepsius of Berlin, "Deutschlands Chem. Industrie 1888-1913," and from that by Dr. Duisberg, of Elberfeld, "Wissenschaft und Technik," 1911.

[2] Mellor, "General and Industrial Inorganic Chemistry," 1912.

[3] Clayton.

[4] There was no University in Berlin until 1809, but the following figures will show how Prussia has made up for lost time in this respect. In 1913-14, there were 7,613 male and 770 female matriculated students, and 4,118 male and 89 female non-matriculated students. The annual income was $1,251,550, of which $1,033,350 came from the state, $204,500 from fees, etc., and $3,800 from other sources. The annual expenditure was $1,251,550, of which the teaching staff accounted for $535,960; departmental expenses, $500,700; building expenses, $53,050; reserve, $33,400; administration, bursaries, etc., $120,450. ("Minerva," 1914.)

[5] C. W. Fielding, *Morning Post*, January 23d, 1915.

[6] Hectare = 2.5 acres.

[7] Quintal = 100 kilogrammes.

[8] Molinari, "General and Industrial Org. Chem.," 1913.

[9] Discovered by Tennant in 1799.

[10] This reaction had for many years been used by Messel in England, but only for the manufacture of SO_3.

[11] The Clayton Aniline Company and Nobel's Explosive Works have contact sulphuric acid plant.

In 1882 the world's consumption of soda was 700,000 tons (190,000 ammonia-soda), and in 1902, 1,760,000 tons (250,000 Le Blanc). In England, in 1876, $35,000,000 was invested in the industry, which gave employment to 22,000 workpeople. In 1880 the British output was 430,000 tons, and in 1890 it was 800,000 tons. North America in 1886 produced 1,100 tons, and 300,000 tons in 1898; and Germany in 1878 made 42,000 tons, 300,000 tons in 1901 and 400,000 tons in 1910.[12] The first soda works in Germany was only erected in 1843 by Hermann at Schönebeck, near Magdeburg, and the first leaden chamber by Kunheim in 1844 on the Tempelhof Plain near Berlin. (See also the statistics in Table I).

HYDROGEN INDUSTRY.

The electrolytic production of soda and chlorine is, of course, attended with the evolution of enormous volumes of hydrogen. At first this gas was allowed to go to waste, but gradually interesting and important uses have been found for it.

1. Dirigible balloons have been rendered possible by taking advantage of the lightness of the internal combustion engine. One horse-power engines are but little heavier than 1 kilogramme. Twenty-seven thousand cubic meters of hydrogen is required for a modern airship. The balloon sheds are often established near electrolytic soda works, or the gas may be transported in steel cylinders compressed to 150 atmospheres. Five hundred cylinders containing 2,750 cubic meters of gas are placed on one railway wagon and more than eight such loads are required for the filling of a single Zeppelin.

2. Autogenous welding with oxyhydrogen flame, a most important application of hydrogen, was introduced at the beginning of this century by the Chemische Fabrik Griesheim-Elektron. The oxy-acetylene flame is now more commonly used.

3. Artificial gems are made by means of oxy-hydrogen flame. Some thirty years ago C. V. Boys succeeded in fusing quartz with the oxyhydrogen flame and then drawing it out into incredibly thin fibers, which have proved of the highest value for certain physical experiments of extraordinary delicacy. The same source of heat was much later, in the nineties, employed by the French investigator, Michaud, to reconstruct rubies from small fragments of this gem. At the beginning of this century Verneuil and Paquier, in Paris, succeeded in making synthetic rubies. A little later Wild, Miethe and Lehmann in Germany elaborated methods for producing synthetic corundum, rubies, amethysts and sapphires, which are manufactured by the Elektro-chemische Werke at Bitterfeld. These products are identical in chemical composition and physical properties with the natural gems, and the rarest varieties of these can be obtained at will. Fused alumina (very pure) gives corundum; fused alumina + 2½ per cent chromic oxide gives ruby; fused alumina + magnesia and titanium oxide and ferric oxide gives blue sapphire. These synthetic gems are now manufactured to the extent of about 6,000,000 carats annually (1 carat = 0.205 gramme), or 1,230 kilogrammes or more than 1 ton. Experienced connoisseurs can, however, distinguish between the natural and artificial gems, with the result that the former have not diminished in value. Natural rubies or sapphires of 2-4 carats cost $100 to $250, and larger stones up to $750, while the artificial would only coast 1/500 to 1/1000 of those amounts.

A still more recent and much more important application of hydrogen is for the hardening of fats, which depends on the transformation of unsaturated into saturated acids by means of hydrogen in the presence of a catalyst (nickel, palladium, etc.).

INDUSTRIES CONNECTED WITH ARTIFICIAL ILLUMINATION.

The world is greatly indebted to Germany for inventions which have largely revolutionized artificial illumination, firstly, in connection with gas and more recently in respect of electric lighting.

Thus, one of the most remarkable discoveries in this domain was that of incandescent gas lighting, which was made by the Austrian Count, Dr. Carl Auer v. Welsbach of Rastersfeld in Styria, as the result of lengthy, laborious and ingenious researches. The now so familiar gas-mantles are prepared by the ignition on the cotton frame of a mixture of 99 per cent of thorium nitrate and 1 per cent of cerium nitrate.

The source of these rare earths is monazite sand, the elaboration of which has become a very important industry depending on fractional crystallization, which already many years ago was brought to such a high pitch of perfection in the laboratory of Sir William Crookes. Out of this monazite sand Hahn in 1910 succeeded in extracting mesothorium and the process is carried out on a large scale at the works of Dr. O. Knöfler and Company at Plötzensee near Berlin. Radium bromide is worth about $85 a milligramme, mesothorium about $37.50 a milligramme. The mesothorium is only present in the monazite sand in extremely small proportion, about one part in 150,000,000.

I may also refer to Auer-metal, a preparation of iron (Fe 30 per cent) containing cerium, which sparks when scratched with hard steel, and which is familiar as a substitute for matches.

Another outlet for the use of hydrogen has been in reducing the rare metals osmium (melting point 2,500 deg. Cent.), tantalum (melting point 2,300 deg. Cent.) and tungsten (melting point 2,850 deg. Cent.).

In 1903 the Auer Company showed that the carbon filament of electric incandescent lamps could be replaced by an osmium filament, with an economy of 50 to 60 per cent of current. In 1905, Siemens und Halske showed that a tantalum filament was cheaper and more advantageous, and in 1906 that the tungsten filament was even still better. Tungsten occurs in sufficient quantity in nature as wolframite (iron tungstate) and scheelite (calcium tungstate) to enable the metal to be now sold as filament-metal for $1.50 to $1.75 a kilogramme.

TABLE I—PRODUCTION IN TONS, 1910*

	Germany	England	France	United States	Europe	World
Sulphuric acid (H_2SO_4)	1,280,000	1,000,000	500,000	1,200,000	3,700,000	5,000,000
(of this by contact process)	400,000	....	....	250,000	....	....
Soda	400,000	700,000	200,000	260,600	....	2,000,000
(of this Le Blanc soda)	30,000	120,000	....	....	....	180,000
Saltpeter consumption	786,000	93,000	337,000	528,000	1,740,000	2,280,000
(of this for nitric acid)	150,000	....	....	50,000	....	....
Hydrochloric acid (30 per cent)	450,000	**	....	....	....	....
Bleaching powder	100,000	....	....	....	....	300,000
(of this electrolytic)	70,000	....	....	....	....	180,000

*Duisberg, "Wissenschaft und Technik," 1911.

**Already in 1898 the estimated production of hydrochloric acid in England was 1 million tons, and for the whole of Europe 2 million tons (Molinari).

Some idea of the enormous and increasing scale on which the incandescent lamp manufacture is carried on in Germany may be gathered from the figures in Table II.

TABLE II—PRODUCTION IN GERMANY.

	1911	1912
Metallic-filament electric lamps	47,211,892 pieces	76,185,721 pieces
Carbon-filament electric lamps	24,791,198 pieces	20,975,348 pieces
Incandescent gas mantles	126,050,954 pieces	135,320,173 pieces
Arc-lamp carbons	10,740,025 kilos	11,093,184 kilos

According to V. B. Lewes, the consumption of gas-mantles in 1912 was: Germany, 100,000,000; America, 60,000,000; England, 38,000,000; France, 16,000,000; Belgium, 3,500,000; Italy, 3,000,000; Russia, 1,500,000.

The special tax imposed in Germany on lighting apparatus realized from the above sources in 1912 was $4,000,000.

AMMONIA.

Of the commoner inorganic chemicals which are produced on the largest scale, one of the most important is ammonia, which has for many years been obtained as a by-product in the manufacture of coal gas.

So backward was this industry in Germany, that actually even as late as 1874 the ammoniacal liquor from their gas works was run to waste. All the more remarkable is the state of affairs to-day as betrayed by the following figures. The world production of ammonium sulphate was 210,000 tons in 1890, 500,000 tons in 1900, and 1,330,000 tons in 1912. Germany's production of ammonium sulphate in 1912 was about 370,000 tons.

The principal use of sulphate of ammonia is as a nitrogenous fertilizer, as which it competes with Chili saltpeter; they may be taken as of equal money value per unit of nitrogen. In this connection Germany's manure bill, given in Table III, is interesting.

TABLE III—GERMANY'S MANURE CONSUMPTION.

	1888 Tons	1912 Tons
Chili saltpeter*	225,000	650,000
Sulphate of ammonia	50,000	500,000
Superphosphate	350,000	1,800,000
Basic slag	250,000	2,300,000
Crude potash salts	160,000	3,000,000
Lime	} 500,000	800,000
Other manures		500,000
Total value		$150,000,000

*The total import of Chili saltpeter into Germany in 1912 was 800,000 tons, of which only 150,000 tons was used for manufacture of potassium nitrate and nitric acid.

It is the ambition of the Germans, firstly, to make themselves independent of the industrial products of other countries, and secondly, to produce in excess of their own needs and to impose this surplus on the rest of the world. Thus, they pride themselves on displacing more and more of the foreign Chili saltpeter by home-made sulphate of ammonia, and in 1911 they used in agriculture 75,000 tons of ammoniacal nitrogen against 70,400 tons of foreign saltpeter-nitrogen. This partial success they look forward to making complete and decisive by developing new methods of producing ammoniacal nitrogen and nitrates.

Of such methods there are already two in operation, and they are associated with that great problem which confronts mankind as a whole. How to supply the combined nitrogen, which will be necessary to build up the food-stuffs for the teeming millions of the future, after the deposits of Chili saltpeter are exhausted? This is the same problem as that of fixing the nitrogen of the air, which long ago, before anything was known of nitrogen at all, man had solved empirically by growing leguminous plants in the rotation of his crops, thereby increasing the fertility of the soil, although the mechanism of this time-honored procedure was only experimentally demonstrated in the last decades of the nineteenth century by the German investigators, Wilfahrt, Hellriegel and Nobbe.

FIXATION OF ATMOSPHERIC NITROGEN BY INORGANIC MEANS.

1. This has been successfully accomplished by the Birkeland and Eyde electric furnace, and the Schönherr electric furnace of the Badische Anilin und Soda Fabrik. These are simply realizations on the industrial scale of laboratory experiments made by Cavendish 130 years previously. This method is applicable only in Norway or other countries where abundance of water power renders the production of cheap electrical energy possible. It is being carried on by an international company at Notodden in Norway. They propose to use 300,000 horse-power capable of yielding 150,000 tons lime-saltpeter (15.20 per cent N) or about one twelfth of the total amount of Chili saltpeter used by the world. Germany possesses but little water-power so that this process is of only indirect interest in connection with German chemical industry.

2. Nitrogen may also be fixed by calcium carbide at high temperatures. This discovery was made by the German chemists Frank and Caro. $25,000,000 capital is already embarked in this industry by various companies of Europe and America. About 120,000 tons is produced annually, about one quarter of which in Germany. The crude calcium cyanamide (about 20 per cent N) may be used directly as a nitrogenous manure or may be made to yield ammonia. The production of calcium carbide involves the use of electric furnace and hence cannot be carried on economically on a very large scale in Germany owing to the limited water-power.

3. Nitrogen and hydrogen may be combined at higher temperature and especially under high pressure. The long known fact that the reaction, $N_2 + 3H_2 = 2NH_3$ is realized to a very small extent at high temperatures has been investigated in recent years by Haber and Le Rossignol at Karlsruhe, and, guided by the principles of modern physical chemistry, Haber has elaborated, after overcoming extraordinary technical difficulties, an industrial process which promises to be of great importance in the future. The most advantageous conditions were to be found: Pressure, 200 atmospheres; temperature, 500 deg. Cent.; catalytic agent, osmium, uranium, etc.

Production of ammonia by the Haber process has been carried out on a commercial scale by the Badische Anilin Company since the summer of 1913, and a plant capable of yielding 130,000 tons of sulphate of ammonia per annum was to have been ready during the present year. Inasmuch as the German Color Syndicates have severed their connection with the Norwegian niter undertaking, it would appear that they regard the Haber ammonia process as being more likely to be capable of capturing the inorganic nitrogen market of the world.

This synthetic production of ammonia obviously involves cheap hydrogen. I have already referred to electrolytic hydrogen, but there are cheaper sources. Thus water-gas contains theoretically equal volumes of hydrogen and carbon monoxide; the carbon monoxide (boiling point—192 deg. Cent.) can be removed by liquefaction from the hydrogen (boiling point—252 deg. Cent.) Similarly the nitrogen required for the process is obtained from the fractional distillation of liquid air. The synthesis of ammonia thus dovetails with the possibilities of cheap low-temperature production for which the world is so largely indebted to the German engineer Carl von Linde of Munich.

The German ambition to make their combined nitrogen at home does not stop at the production of synthetic ammonia, for there are still large requirements in respect of nitrates (Germany produces upward of [illegible] 500,000 of nitric acid annually from Chili saltpeter) which have to be satisfied from foreign sources. They hope, however, to fill this gap in the home production of combined nitrogen by utilizing a reaction discovered by Kuhlmann[13] as long ago as [illegible], in which ammonia and air burn to nitric acid in the presence of platinum as a catalytic agent.

(To be continued.)

[12] Molinari

[13] [illegible]

The Earth Considered as a Heat Engine*

A Chapter in the Thermodynamics of Nature

By George F. Becker, United States Geological Survey

Imagine that the earth solidified in such a way that fluid equilibrium were perfectly preserved and that the exterior were perfectly smooth, presenting an ideal equipotential surface of uniform temperature. Suppose that the only differences between different portions of this surface were in the diffusivity (that there are large variations in the diffusivities of different rocks, the published determinations clearly show). For simplicity's sake, suppose that a certain square area had a uniform diffusivity smaller than that of the surrounding surface. It is evident that this square would cool more slowly than the adjacent portions, and by reason of the slower escape of heat it would develop a slight relative elevation—provided indeed that the material of the globe contracted in cooling as almost all substances actually do. Furthermore, the relative contraction of the surrounding mass would bring to bear a pressure on all four sides of the square, and this pressure would extend downward as far as the difference of temperature was sensible. Such a pressure might even suffice to rupture the rock within the square.

Thus a difference in diffusity would bring about an intumescence on the surface of the globe followed by the formation of four systems of joints, which, in the simple case supposed, would cross one another at right angles at the surface, and dip at about 45 degrees in four directions.[1] These joints are equivalent in voids, which as I have recently shown may, in extreme cases, approach 6.73 per cent of the volume.[2] Thus a further very considerable intumescence or uplift would result, and an additional diminution in the diffusity, because joints interfere with the conduction of heat. This diminution would further increase the depth to which sensible differences in temperature on the same horizontal plane would extend. Besides systematic rupture it is evident that the lateral pressures on the square column would, or might, bring about deformations and the crumpling of layers originally plane.

It would seem then that the initial difference in diffusivity need not be great eventually to ensure a considerable uplift within the hypothetical square, since so soon as it sufficed to establish a temperature difference of a few degrees, the process of uplift would be increased by the effects of rupture.

Supposing no water to exist upon the earth, the square column under discussion might attain a notable elevation. The average land surface now stands about 4 kilometers or two and a half miles above the average sea bottom, and if the material from which the salt of the ocean has been derived represents eroded continents of present area, the average land surface might have stood some 2.5 kilometers higher than it now does. Whether so lofty a mass could sustain its own weight need not be discussed here, the present object being merely to bring out a particular feature of the whole problem.

The internal temperature of the continental mass likewise calls for consideration. At the present day the mean depth of the ocean is about 3,486 meters, the mean elevation of the land is about 440 meters and the mean thermometric gradient 1 degree in 38 meters, or possibly as high as 1 degree in 32 meters. The temperature at the bottom of the sea is not far from zero, while at the same level beneath the continents it is over 100 degrees. Thus the mean temperature of the actual continents down to the level of sea bottom is more than 50 deg. Cent. above the temperature of the sea-bottom itself, while for a long distance below this level the sub-continental masses must be hotter than the sub-oceanic layers. (Even if no energy were dissipated within the continental plateaus, the rate at which heat would be conducted from the subterrestrial to the sub-oceanic regions would be exceedingly low.)

Some of this temperature excess is probably a remnant of the original temperature of the globe, equivalent to that which has failed to escape because of the low diffusivity of the continental rocks. Another portion, probably considerable, represents kinetic energy dissipated in crumpling and plication of the continental mass. On the hypothesis under discussion all of this temperature excess and all of the energy of position represents heat which would have been radiated into space had all parts of the earth's surface been endowed with equal diffusivity.

The outer shell of the earth down to a depth of perhaps 70 or 80 miles at which the primeval temperature still prevails without sensible diminution may thus be regarded as an imperfect heat engine, receiving heat energy at an absolute temperature approaching 2,000 degrees, and emitting it at less than 300 degrees. The difference is proportional to the energy which would be available were this engine perfect. Though far from perfect it has sufficed, it seems to me, to supply what has been expended in maintaining in part the relatively high temperature of the sub-continental masses, and also in epeirogenic and orogenic upheavals, in the shattering and crumpling of rocks, and in earthquakes and volcanoes. (It is to be expected that the dissipation of energy would be peculiarly intense near the surface, dividing the rising continental columns from the oceanic basins. It is in such positions that most of the volcanoes are found.)

So far the ocean has been practically ignored, but only a few years can have elapsed after the consistentior status before the sea came into being. Even a very small difference in diffusivity, acting for a very short time, would have served to outline depressions into which the incipient ocean would gather while, after a time at any rate, the presence of the ocean with its convective circulation would tend further to increase the difference in temperature between the areas of relatively great and relatively small diffusivity, which would then become oceanic basins and continental plateaus.

The moment an ocean formed, or rather a moment before it began to form, erosion commenced and introduced a new factor into the world system. Were the globe completely covered by the sea, evaporation and precipitation would furnish no energy of geological significance. The energy absorbed in evaporation would be liberated on precipitation, and the molecules of water would return to their original level. But water falling on a continent and carrying sediment to the sea depotentializes or sets free the energy of position acquired at the expense of the heat stored in the earth.

At great depths we know that rocks are deformed and undergo solid flow; and it is well known that under an appropriate system of stresses any solid must flow.[3] At the surface, so far as rocks are concerned, such a system of stresses does not exist, and the rocks do not flow. But erosive action lends them a mobility almost equivalent to fluidity, so that the net result is in some respects analogous to that which would ensue if the solid surface of the globe were replaced by a mass of hyperviscous liquid, some column or columns of which had a higher temperature than the surrounding matter. These columns would rise above the general surface because of the diminished density and the mounds thus formed would overflow or run down because they lack rigidity. The outflowing portions would cool, and sinking into general mass, would establish a convective circulation.

Not just in the same way, but similarly, erosion effects the flow of the continental surface matter to or beyond the edge of the continental plateaus, overweighting the ocean floor and bringing about a corresponding subsidence.

In an asphalt lake like that of Trinidad convection due to lack of temperature equilibrium would be attended by an undertow. Material rising from any particular depth would diminish the horizontal pressure, which it had previously exerted on surrounding portions of the hyperviscous mass, and these would press inward to fill the partial void. In a solid earth there must be an analogous action, excepting that the partial pressure needful to produce lateral flow or undertow must exceed that which would strain the solid rock to its elastic limit.

The analogy of an asphalt lake must not be applied without caution. In such a lake it is easy to conceive of convective circulation indefinitely continued. Not so in the solid earth. If the whole rock mass from which the oceanic salt has been derived was really once piled on the continents, and if the ocean is 100 × 10⁶ years old, then the total uplift of about 6½ kilometers has only been effected at the rate of 1 millimeter in 15 years or 1 inch in 380 years. Thus the process might be compared with *incipient* convection in an asphalt lake.

None the less, so far as it has gone, the undertow has tended to contract the area of incipient continents, to increase the crumpling and to exaggerate the elevation to which they would have attained had there been no convective tendency.

On the hypothesis that the origin of continents is due to the inferior diffusivity of certain areas of the earth's surface, the conditions of the ocean's bottom is very noteworthy. As is well known this floor is relatively featureless, consisting of vast plains, low ridges, and a few deeps, seven-eighths of its area lying at a depth of more than a kilometer below sea level. There are very few indications on the ocean floor of continental topography, and yet if a continent were to be submerged to a depth of a hundred fathoms or more, that is below the reach of wave action, it is difficult to see how any process of base-leveling could reduce its accentuation. Neither on the hypothesis under discussion is it easy to see how a continent could be submerged, though it is barely possible that a thin layer of rock of small diffusivity might be removed by erosion, leaving exposed masses of diffusivity so high as to undergo rapid contraction. Judging from the bathymetrical maps there are no important cases of this description. It would seem that, as the elder Dana so ably maintained, the oceanic areas have been persistent; and if so the subsidences which have occurred and recurred have been subordinate features of movements the net result of which in each case was uplift. This is in line with the results of Hayford, Helmert, and their associates. Since they have compelled us to concede that the earth is even now in a condition of approximate isostatic equilibrium, it seems impossible to believe that it has not been so in the past. Erosion has been in progress during every era from the Algonkian upward, and there must have been a persistent and prevailing tendency to upheaval. Of a complete drowning of the continents, such as would occur during a prolonged era in which subsidence prevailed, there is now no trace.

Two reasons have been suggested above for the high level at which the continents stand relatively to the ocean floor, viz., superior temperature and the existence of voids. The difference in level is 3,930 kilometers or 0.032 of 122 kilometers. If this difference were entirely due to excess of temperature, and if the linear expansion of average rock is 0.0008 per degree, the whole elevation of the continental columns would indicate a mean temperature of difference of 40 deg. Cent. If this elevation were due *entirely* to the existence *of* voids these would amount to about half the maximum interstitial space found for me by Mr. Melcher in experiments on the crushing of sulphur in sealed brass tubes. It is evident that the two causes in combination might bring about elevations not only corresponding to the mean height of the continents, but also to those of lofty mountain ranges.

Until erosion began the terrestrial mechanism must be regarded as a heat engine of the irreversible type. It could potentialize energy and do mechanical work, but the cycle was incomplete. When erosion supervened and conferred upon the superficies of the continents a certain mobility and kinetic energy, the cycle was completed and the stage answering the adiabatic expansion was supplied.

It is true that the efficiency of this engine must be very small, but the store of energy upon which it draws —the available boiler capacity - is enormous. The mechanism thus appears competent to bring about all of the dynamical effects with which geology has to deal.

* [illegible] address by George F. Becker, of the United States Geological Survey, before the National Academy of Sciences, [illegible]

[1] [illegible] Proc. Wash. Acad., 7, 2?? (1905).

[2] [illegible] (1912).

[3] Thomson, Math. Theory of perfectly elastic solids, 1887, p. 174.

Measurements of the Planet Saturn

From a photograph of the planet Saturn taken by Barnard at Mount Wilson in 1911, with the 60 inch reflector, using an equivalent focus of 100 feet, P. H. Hepburn has made a series of measurements. Several striking discrepancies are shown by these photographic dimensions from the values derived by several observers visually, and a plotted chart of the ring system brings this out very clearly. In the discussion as to the cause of the difference, it is considered whether it may be due to systematic errors in the micrometric movements of convex compared with concave outlines, or differences in the photographic or visual images; or physical changes in the planetary system. An interesting statement is that the author finds evidence of the transparency of the ring A, and also that its surface is not uniformly bright. An old report by Trouvelot in 1885 is quoted showing that the transparency of the ring A was suspected at that time. Full details are given of the measures of the system in *Roy. Astronom. Soc. M.N.*, 74, p. 721.

Automobile Lubrication—I*

How to Test, and How to Use Various Classes of Oils and Greases

By C. W. Stratford

During the infancy of the automobile industry engineers and operators of motor vehicles had their hands full to keep their machines going at all. Consequently, they had little time or inclination to study the subject of proper lubrication. But as the use of internal combustion engines for the propulsion of automobiles, motorcycles, agricultural tractors, etc., became more universal, and as other operating troubles were finally eliminated one by one, the question of correct lubrication gradually and naturally came to the front with a pertinent plea for attention.

Fig. 3.—Heat test.

The subject of heat motor lubrication, complex as it is, can perhaps best be presented by first considering the chemical and physical properties of the lubricants themselves and the refining processes.

CHEMICAL STRUCTURE OF HYDRO-CARBON MOTOR OILS.

The term "non-carbon" frequently used in the oil trade, obviously for the purpose of misleading the buying public, is not only a misnomer, but a statement contrary to chemical fact. Lubricating oils are hydro-carbons and, as their name indicates, consist of a physical mixture of different chemical compounds of the element carbon and the element hydrogen. No other elements are present except as impurities. Just as cream, butter, cheese and other products are derived from milk, so are hundreds of different hydro-carbon compounds, lying between the extreme limits of gasoline and cylinder stocks or coke, separated from crude oil. Each one of these many compounds has its own peculiar physical properties, such as definite boiling points, etc. American motor oils are manufactured from paraffin, asphaltic, and mixed paraffin and asphaltic base crude oils. The limitations of this paper preclude a lengthy discussion of the exact chemical structure of compounds found in crude oils of different bases, further than to say that paraffin base oil belongs to the methane series, characteristic formula

$$C_n H_{2n+2}$$

while the asphaltic base oils are composed of the series of hydro-carbons containing more carbon to the molecule (unsaturated), characteristic formulæ

$$C_n H_{2n}, \quad C_n H_{2n-2}, \text{ etc.}$$
(olefins) *(acetylenes)*

In addition to compounds of the two principal series, many other different compounds are found in paraffin and asphaltic base oils in variable quantities, depending upon the source of the crude. Russian oil is made up largely of hydro-carbons of the napthene series, characteristic formula

$$C_n H_{2n-6} + H_6$$

Motor oils refined from crude oils of different bases present a very marked difference with regard to their physical properties and chemical stability.

* A paper presented at the Semi-annual meeting of the Society of Automobile Engineers, June 14th–17th, 1915.

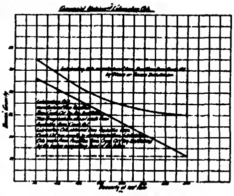


Fig. 1.—Commercial divisions of lubricating oils.

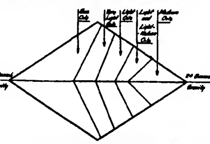


Fig. 2.—Separation of the lubricating distillate.

SEPARATION INTO GROUPS BY DISTILLATION.

Simply stated, the preparation of motor oils consists of a separation of a certain body of compounds which have as a mean the properties required of motor lubricants. All hydro-carbon oils are prepared for the market by one of the two following methods (a) steam or vacuum distillation, (b) dry or destructive distillation. The commercial division chart (Fig. 1) shows a classification of paraffin and asphaltic base oils refined by these two processes. It will, no doubt, also be of interest to many to learn how motor oils are separated, according to their gravities and viscosities, from the "lubricating distillate." The areas within the quadrilateral (Fig. 2) indicate graphically the volumetric and gravimetric separation of this distillate into its market forms. It will be seen that the motor oil area represents a remarkably small percentage of the total area, all of which accounts for the higher price of high-grade finished motor oils compared to other products.

REFINING PROCESSES.

Sulphuric Acid Process.—By this process after the separation of the lubricating distillate into groups, the lubricating oil fractions are treated with sulphuric acid to throw down unstable compounds, free carbon, etc., washed thoroughly with water, neutralized with an alkali and the whole again washed and separated. The oil remaining is then blown with air to remove traces of water that may be present. Another method consists of filtering lubricating oil fractions, which have been partially decolorized by sulphuric acid to complete the decolorization necessary to bring them up to marketable standards. Such oils may be technically called "filtered" oils. The interesting reaction here, due to the sulphuric acid, letting R represent the hydro-carbon radical, is

$$RH + H_2SO_4 = RSO_3H + H_2O$$

and neutralization,

$$RSO_3H + Na\,OH = RSO_3Na + H_2O$$

Fig. 4.—Emulsion test.

Oils refined by these processes are brilliant to the eye and they all contain hydro-carbon sodium "sulpho" salts, varying in quantity with the quality of the oil considered. The effect of the presence of this compound will be studied later.

Filtration Process.—After the separation of motor oils from the "lubricating distillate," they are filtered through Fuller's earth which removes impurities and hydro-carbons of high carbon content. Filtered oils of first-class quality contain no "sulpho" compounds.

CHEMICAL REQUISITES OF MOTOR OILS.

To obtain maximum lubricating efficiency and maximum durability, it is imperative (1) that motor oils contain a minimum quantity of unsaturated hydro-carbons, to prevent rapid polymerization and "cracking," and (2) that the oils contain no "sulpho" compounds or other impurities as a guarantee against the rapid accelerating effect which such acid compounds exert when exposed to heat, upon polymerization and sedimentation. The proper methods of making the heat and emulsion tests to determine the presence of sulphonic acid compounds are as follows:

Heat Test.—Fill a clean bottle or a small Erhlenmeyer flask about half full with the oil to be tested. Heat it up slowly over an open flame or on an electric plate (Fig. 3) until yellow vapors appear above the surface of the oil. (The temperature at which these vapors appear will depend upon the flash point of the oil tested.) Hold at this temperature for 15 minutes. A comparison of the heated with an unheated sample of the same oil tells the story of quality. Good oil darkens in color, but remains perfectly clear and without sediment, even after standing 24 hours, thus proving the total absence of acid compounds. Impure oil, on the other hand, turns jet black. If allowed to stand 24 hours, a black

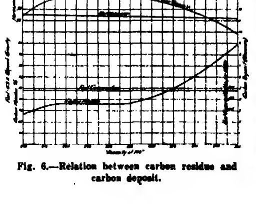


Fig. 6.—Relation between carbon residue and carbon deposit.

Fig. 7.—Saybolt universal instrument.

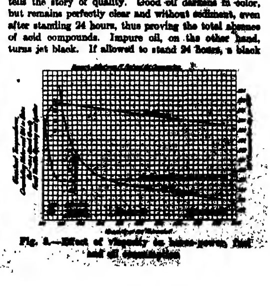


Fig. 5.—Effect of viscosity on brake-power, fuel and oil consumption.

carbon-like sediment settles out, proving the presence of sulphuric or sulphonic acid compounds. This test is so unfailing and so important, that I would recommend it to oil purchasers as a feature to be incorporated in their specifications.

Emulsion Test.—(To be made with 100 per cent hydrocarbon oils only). Fill a bottle (preferably 4 ounce) one third full with the oil to be tested. Pour in an equal amount of water, leaving a space of one third free above

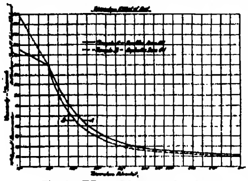


Fig. 9.—Effect of heat on viscosity.

the oil and water. Cork and shake the bottle vigorously 30 minutes in a shaking machine or by hand (Fig. 4). Then set it aside for 24 hours. Good oil shows a fine white line of demarcation between the oil and clear water below, indicating the absence of acid compounds. Impure oil mixes permanently with the water, appearing as a curdled mass, floating upon milky water below. This indicates the presence of sulphuric or sulphonic acid compounds. The curdled portion is a sort of sulphuric acid soap, and the amount of the curd shows the quantity of "sulpho" compounds present. The object of this test is exactly the same as that of the heat test, with the disadvantage that it requires more time. To engineers and others making a study of oils it is worthy of notice, because of the fact that there is a certain quantity of water present in the crankcase of motors, due to the condensation of the products of combustion.

SIGNIFICANCE OF PHYSICAL PROPERTIES.

Four properties only need be recorded as essential in judging the qualities of oils for use in internal combustion engines, Flash Test, Carbon Residue, Cold Test and Viscosity. In addition the Gravity, Fire Test and Color are also considered at the refinery and to some extent in the trade (Fig. 5).

Flash.—By definition the flash point of an oil is the lowest temperature at which the vapors arising therefrom ignite without setting fire to the oil itself when a small test flame is quickly brought near its surface in a test cup and quickly removed. Inasmuch as the temperature of explosion exceeds by several times that of the highest obtainable flash it is clearly apparent that even 100 degrees difference in the flash of two oils can be of no avail in resisting destruction within the explosion chamber. Below the pistons, however, the operating temperature of piston heads and other parts requires the use of high-flash oils for reasons of economy and durability. Motor oils having a flash point much below 400 deg. Fahr. show a very appreciable vaporization loss by way of the breather orifices. This loss increases rapidly with a further drop in flash and increase in crankcase temperature.

Carbon Residue.—There is a certain amount of carbon in all motor oil which can be "fixed" by distilling a given quantity, in a standard flask and at a uniform rate, to the end (Gray method: 25 cubic centimeters, rate one drop per second, destructive distillation). A coating of carbon will remain upon the walls of the flask which is weighed and the percentage of carbon determined. This "fixed" carbon is termed carbon residue and is not to be confused with carbon deposit. In commercial oils the carbon residue increases nearly in proportion to the increase in viscosity, being lowest in the very light oils. The carbon residue, high or low that an oil contains does not necessarily indicate the relative amount of Carbon Deposit (Fig. 6), which will occur, in use, on the explosion chamber walls of a motor. Carbonization is also greatly influenced by the quality of the oil, by its viscosity and flash and by piston-ring leakage. If a motor must be operated with leaky piston rings, then an oil of the lowest possible carbon residue will leave behind the least volume of carbon deposit.

Cold Test.—The chill or cold test of an oil is the lowest temperature at which it will pour. This characteristic need only be taken into consideration in regard to its effect upon the free circulation of oil through exterior feed pipes and sight gages, where pressure is not applied. The cold test is in no way indicative of lubricating or heat-resisting qualities.

Viscosity.—The viscosity (cohesion) of an oil is usually given in terms of time. The number of seconds required for a definite volume of oil under an arbitrary head, to flow through a standardized aperture at constant temperatures (Fig. 7). Readings are commonly taken at 100 deg. and 212 deg. Fahr. In all phases of lubrication the matter of correct viscosity is one of prime importance and its effect is far-reaching. The curves shown in Fig. 8 will point out the effect that viscosity has upon horse-power, and fuel and oil consumption.

Effects of Viscosity.—Even the veriest novice can readily note the difference between the power and rapidity of acceleration of his motor when using a light or medium oil (180 to 350 seconds) as compared to an extremely heavy oil (2,300 seconds). When oils lighter than 180 seconds are used the horse-power falls off very rapidly until the pistons and bearings finally seize, with oil of approximately 100 seconds.

It will be seen that the fuel consumption reaches its minimum when a light oil of about 180 seconds is used. Oil of this viscosity gives the maximum horse-power obtainable with a given engine. As the viscosity increases from 180 seconds the fuel consumption increases uniformly with it. With oils below 180 seconds the fuel consumption mounts to its maximum.

Gravity.

Considering the curve of oil consumption a most extraordinary variation in the quantity of light and heavy oils burned will be remarked. Between 300 and 2,300 seconds the variation is comparatively slight, a

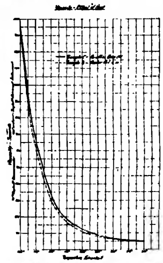


Fig. 10.—Effect of heat on viscosity.

fact which indicates that there is no advantage to be gained by the use of oils heavier in body than 800 seconds. Passing from 800 to the light oils it becomes evident at once that there must be some point (viscosity) where the highest economy of both fuel and oil is attained together with high horse-power. Both laboratory and service tests on the road have demonstrated that this point lies between 300 and 800 seconds and that it depends directly upon the condition of the motors in which the oils are used and upon their average operating temperatures. Were it not for the difficulty of a more rapid carbonization (when heavy oils are used) no oil having a viscosity of less than 300 would be recommended, in the light of these facts. But a practical compromise must be reached; consequently light and medium oils (180 to 300 seconds) are regularly specified as being the most fool-proof in character and hence best capable of meeting the most widely differing conditions of service.

EFFECT OF HEAT UPON VISCOSITY.

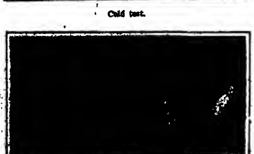
All motor oils when heated become thinner and thinner or in other words lose in viscosity. The rate of this loss, with rise in temperature, is not uniform, nor is it comparative between oils of very light and very heavy body. In addition, oils of different chemical make-up, but of the same body at 100 deg. Fahr., show a decided divergence in viscosity at higher temperatures. Curve *A* (Fig. 9) represents a paraffin base oil and *B* an asphaltic base oil. Though the viscosity of both is equal at 100 deg. Fahr., the viscosity of the asphaltic base oil falls off at a more rapid rate and remains below that of the paraffin base oil throughout the entire range up to 300 deg. Fahr. Curves *C* and *D* (Fig. 10), representing a heavy paraffin base and chemically pure castor oil respectively, denote the comparative rate of loss in viscosity up to 300 deg. Fahr. These curves seem to indicate that castor oil possesses no advantages over paraffin base mineral oil for use in high-speed racing motors.

(To be continued)

Cold test.

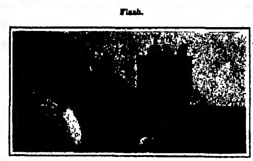
Fire.

Flash.



Viscosity.

Carbon residue.



Color.

Fig. 5.—Testing a lubricant.

The Science of the Cipher

And an Explanation of Bacon's Undecipherable System

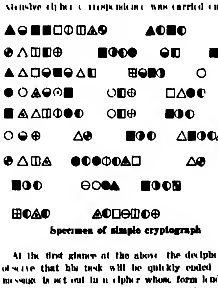
By William W. Brewton

THE creation and solution of cryptographs or illusive writings is an art which by no means has been confined to any particular period of letters. It is an art which was highly perfected by the Egyptian Ptolemies and which has engaged the attention of royal secretaries from the very earliest times. It perhaps figures more prominently in fiction than elsewhere in modern times. Few writers to-day who possess anything like an analytical turn of mind fail to make use of the cipher, realizing that it has always been of wide interest to readers.

Edgar Allan Poe, a master in this sphere of thought, has asserted that "it may well be doubted whether human ingenuity can construct an enigma of the kind which human ingenuity may not, by proper application, resolve." However, Francis Bacon, Baron Verulam, who has been called the founder of modern science, once wrote that the art of deciphering was a work of labor and ingenuity, yet by diligent precaution it may be rendered useless, for if the ciphers in use were good and trusty several of them would absolutely elude the labor of the decipherer and yet remain commodious enough so as to be readily written and read.

It may be said that there are two general methods by which a person who wishes to solve a cipher may effect the gathering together and comparing those circumstances which seem to indicate the meaning and intentions of the writer, and the solution from the formation and arrangement of the very characters of the cipher themselves. Both of these processes of course are generally used before a complete solution is attained, but the decipherer will usually begin with only one, the method which his observation of the cipher indicates will secure the earliest solution. A solution from the very characters of the writing themselves is the method pursued when these characters are presented in some regular related and suggestive form. When thus arranged the decipherer will be able usually to ascertain the alphabetical key to the writing, and by applying this key throughout he may resolve the entire cipher.

As an illustration of the type of cryptograph which may be resolved from its form and appearance the author will exhibit one which he once received from a former schoolboy friend, written when this friend was still a lad of sixteen years and with whom quite an extensive cipher correspondence was carried on.



Specimen of simple cryptograph

At the first glance at the above the decipherer will observe that his task will be quickly ended, for the message is set out in a cipher whose form lends every aid. The words are separated conveniently, and there is a constant recurrence of similar characters which clearly enough are the letters of words. At any rate the decipherer would proceed upon this simple plan until he saw that he had underestimated the complexity of the cipher. In reading this message it would be noted at once that the first word is not the place at which to begin in search of a key. For the first step in arranging a key would be conjecture or more or less certain guesswork, and the first word is too long, has too many letters to be easily guessed at. The decipherer would naturally look for a word whose entire list of letters he might conjecture and thus secure as quickly as possible the maximum number of letters in the cipher alphabet. He notes that there is one word of only one letter at the end of the third line. This will be either the word I or O or A. He guesses *A* because he has observed that in the very next line is a word of three letters which suggests itself as *and*, and which begins with the same character. Especially would he venture this conjecture when he notices immediately under this word another just like it. Inasmuch as the word *and* is one which occurs frequently, whether in short or lengthy messages the decipherer feels reasonably certain that his guess is correct. With the three letters thus obtained he now seeks for some other word containing them or part of them in order to substitute as far as possible and conjecture the remainder of such a word. But before doing this he may reasonably guess that the word appearing at the end of the fifth line is *the* inasmuch as the same word occurs also in the very next line when it is well known to him that *the* is a very frequent word in all writings and that it is a word which very naturally follows the word *and* which he has already obtained to a reasonable certainty. Now there would be no necessity of beginning a substitution of the letters reasonably obtained in other words as long as there are a number of brief words to speculate upon. In the sixth line there is a word of two letters (the second word) which also occurs as the last word of the seventh line. The words *at*, *to* or *of* suggest themselves as probable, but we at once discard *at* and *to* or even the word *on* inasmuch as it is known that the letters *a* or *t* or *n* do not occur in the word which is being deciphered, inasmuch as it has already been ascertained that there are other and different characters representing them in other words. So it is concluded that the word must be *of*, against which conclusion there is no reasonable objection anyway. If we substitute the letters we have derived in the word at the end of the sixth line which seems to contain several of the conjectured characters we soon obtain the word *other*, the letters *h* and *r* being the only ones we must again conjecture. This word is accepted as correct until it is proved not so. The third word in the second line is readily guessed as *is* inasmuch as the second letter has been ascertained to be *s* and the first letter cannot be *o* to make the word *os*, a character for *o* having been already ascertained.

By continuing to look for words containing ascertained characters the decipherer notes the first word in the seventh line whose every letter he has decided except the third. By substituting the deciphered letters the word *four* is the only reasonable one which suggests itself and one more letter *u* is obtained. By substituting in the first word of the fifth line the answer to it is the word *trouble*, it being necessary to conjecture only the fifth and sixth letters. Immediately under this word on the sixth line the decipherer concludes the word *aid*, having obtained all the characters of this word in solution. The entire cipher is in two sentences and we may read a part of the second by substituting only a few other instances. We read beginning at the first of the second sentence: "With a lariat and some trouble and the aid of the other four members of the ..." By proceeding with the method we have pursued the entire solution becomes:

> Pittsburgh Pete found them in this position. With a lariat and some trouble and the aid of the other four members of the camp they were rescued.

The above cipher of course, is one very easily solved, but in solving it we illustrate the method which is used in the case of those ciphers which offer a key through their form or construction. By complicating the appearance of his message the cipher writer will render a thousandfold more difficult its solution. Where the words are undivided conjecture of letters and short words is prevented. Yet Poe is very near the truth when he asserts that few consistent messages can be arranged which cannot be solved. If the message is of any reasonable length, the recurring character representing some alphabetical letter will finally suggest some meaning. With his solution of course, the decipherer must correlate the principles of language, many of which are the same in all tongues.

For dispatch and convenience, ciphers are often written in war times by one general to another on the same side by simply writing out a number of sentences giving a particular direction which in reality will have the opposite meaning from the one indicated by the message. If such a message should fall into the hands of the enemy, its solution would be attempted by proceeding to reason out the true message which was sent. The general circumstances existing at the time might indicate to the decipherer that instead of "attack" the message conveyed the order to "retreat," though the actual words of the message indicated the former. It is the purpose of cipher writers in armies to convey in their messages as simple statements as possible in order to free them from suspicion. In military affairs, and also in the secret affairs of State, complexity in ciphers excites suspicion, and attracts too much attention. The ability to convey convenient and accurate and easily interpretable secret messages, in regular language and in ordinary sentences, is the art which is to-day sought by those who must necessarily use the cipher.

A highly useful and at the same time practically undecipherable scheme for cipher writing was invented by Bacon when a youth of about seventeen in Paris. It is a method of expressing as he termed it, "anything by everything," and the only condition or limitation placed upon its use is that the matter included be five times less than that which includes it. This condition arises by reason of the fact that each letter of the cipher alphabet is represented by five letters of the writer's ordinary alphabet. Five letters are chosen because this arrangement will admit of 32 changes, and therefore will embrace a change for each of the 24 letters of the English alphabet. Bacon's arrangement is as follows, the changes of five places being represented with the use of only two letters:

A is represented by	aaaaa	N is represented by	abbaa
B	aaaab	O	abbab
C	aaaba	P	abbba
D	aaabb	Q	abbbb
E	aabaa	R	baaaa
F	aabab	S	baaab
G	aabba	T	baaba
H	aabbb	U	bbbbb
I	abaaa	V	baabb
J	bbbba	W	babaa
K	abaab	X	babab
L	ababa	Y	babba
M	ababb	Z	babbb

Under this scheme, for example, if we should wish to write the word Fly it would be thus formed:

F	L	Y
aabab	ababa	babba

Suppose also that there be adopted two forms of letters, as for example the Roman and the Italic, and that each Roman letter represent A and each Italic letter represent B. Then a cipher of the above plan could be woven into a message of one's natural and usual vocabulary. One could send a message to "fly," for instance, by sending the words "Stay til I come to you." The message with its interpretation would be thus:

aabab	ababa	babba
Sta*y* *t*	*i*l*I*co	*me* t*o* *yo*u

though, of course, the message sent would be simply:

Stay til I come to you

There would be here no significance to the final *ou* in the sentence, but the person to whom the message would be sent would have no difficulty in extracting the real, internal message. In case the cipher were written by hand with pencil or pen the italicized letters could be indicated by underscoring at the proper place. In order to render the message still more difficult to solve, it might be lengthened into one of twenty-five or fifty words, underscoring or leaving plain in the non-significant places in such a manner as make them of no effect, and therefore to keep them from conflicting with the words which convey the secret message. For instance, if we follow the plan of letting italicized letters represent B, and the plain letters represent A, the internal message "We retreat at midnight," is conveyed in the following:

> General Greig advances upon the enemy's left at daybreak. Throw your right in position to cover his prospective retreat, and engage the enemy's right if he holds his ground.

For convenience it may be agreed that all [illegible] sages shall begin with a certain letter of the [illegible] and visible writing. For example, in the above we begin the secret message with the [illegible] in advance. From that letter [illegible] the word engage, is a significant [illegible] sage, "We retreat at [illegible] with some definitely [illegible] person to whom the [illegible] from the [illegible] that point. [illegible] begin with the [illegible] allow considerable [illegible] decipherer before he [illegible]

of the writing. To render the matter still more complex, the persons carrying on the secret correspondence might adopt the pre-arranged plan that every fifth word shall be significant, or that there shall be a significant word after the first twenty words of the visible writing and then there shall be thirty non-significant words to be followed by fifteen significant ones to be followed by forty non-significant. Of course all non-significant words shall be written with Roman and Italic modifications, just as the significant ones, in order that there shall be room for no suspicion upon any particular part of the writing. Before the word *advance*, and after the word *engage*, in the above cipher, the words are non-significant, though presenting an appearance similar to the other parts of the writing. By translating the Italics into B's and the Romans into A's in *General Greig*, for example, and then grouping five letters in one place to make a letter of the true message, it is found that the arrangement furnishes nothing of any meaning, and such parts of the writing, of course, the person receiving it may disregard. The greater the length of the writing, compared to the length of the inner message, the more difficult will be a solution by a person who does not know the plan of forming it; which is directly contrary to what is true concerning such a cipher as is found in Poe's *Gold Bug*, or any cipher which may be resolved by observing its form and construction. A cipher of individual unknown characters, if consistent throughout, will be the easier to resolve, the greater its length; inasmuch as in resolving it one would wish to observe the characters related in as many different ways as possible. While a cipher which must be resolved by ascertaining the circumstances associated with it, and deducing from them its meaning, will be the easiest of solution when it is briefest, when there are fewer conflicting ideas and fewer words. In the cipher above, the form would be suggestive to the decipherer as well as any conclusions he might attain from its visible wording and from the meaning of the visible writing itself, for the modified shape of the letters would indicate some significance. However, where the letters of both the ordinary and the secret messages are alike, and the one is simply folded, or secretly placed, within the other, form indications do not mean very much to the decipherer, and a cipher arranged on this plan will prove itself the most difficult of solution.

If time for arranging a cipher message were of no consequence, it would be a fairly easy matter for one to arrange a secret message within a visible writing and place thereon no form indications at all. For instance, instead of determining B's by an Italic letter and A's by a plain letter, it could be adopted, as a pre-arranged plan between the corresponding parties, that every letter in the visible writing which is followed by a consonant shall be an A, and every letter followed by a vowel shall be a B; or that every letter of the writing followed by one of the first thirteen letters of the alphabet shall be an A, and where followed by one of the last thirteen letters of the alphabet it shall be a B. But to so frame an outer writing as to accommodate this highly restricted arrangement would be impracticable both because it would require too much time to do so, and because at times it would be necessary to use words whose meaning would be not at all connected with that of the rest of the writing, in order to come within the pre-arranged sequence of letters. A plan of this kind could be made and used where the correspondents have no demand of dispatch, either in writing or reading, upon them; but for practical purposes, as war or hasty diplomatic correspondence, the writer and reader must avoid such delays as this plan imposes. The writer desires to be able to write out his message instantly upon forming it in his mind without having to run through all the words he can call to mind in order to use those which will conform to any plan. By using the biliteral alphabet of Bacon's the cipher writer may make any exterior writing convey any secret message, and obviously this plan is the one which has the greatest facility and which is, therefore, the most practical. The question of how the A's are to be determined from the B's is a matter which should be left to the correspondents themselves, any plan of marking the visible letters being practical so long as it may be observed by the reader, whether clever enough to elude the notice of the illegitimate decipherer or not.

For practical cipher writers, the objective is adaptability to circumstances and freedom from unique or suspicious appearance.

Coal Mined by Machines

The substitution of mechanical methods for hand labor in the bituminous coal mines of the United States during the last quarter of a century has been one of the most interesting features connected with that branch of the coal-mining industry. It would have been a physical impossibility to have attained the present enormous production of bituminous coal (nearly half a billion tons in 1913) if it had been necessary to depend upon hand labor alone. The results accomplished by the use of mining machines are threefold: (1) The exacting character of the miners' employment is much ameliorated; (2) the percentage of lump coal is increased, which means a better average price for the total product; and (3) the cost of production is reduced. The first is of a humanitarian character, but the two last, which are purely economic, have been the chief incentives in the changing of mining methods which has made the mining of bituminous coal in the United States during the last twenty-five years an epoch in the history of the industry. In many cases the installation of mining machinery has been forced upon the operators by the constantly advancing cost of labor and the necessity for keeping mining expenses within the lowest possible limits because of the keen competition and the low selling prices which have existed for many years in the principal coal-producing States. In 1890, the first year that the statistics of labor employed in the coal mines of the United States were collected and when the use of mining machines were just beginning, the average production of bituminous coal per man employed was 579 tons and the total production was 111,302,322 short tons. In 1913 the mine employees averaged only six more days in the year, the average production per man was 837 tons, and the total production was 478,523,203 short tons, about 4.3 times that of 1890. But in 1913, 242,476,559 tons, or a little more than 50 per cent of the *total*, were machine-mined, whereas in 1890 probably less than 5,000,000 tons (not 5 per cent of the total) were machine mined. At the same rate of production per man as in 1890, the total output of bituminous coal in the United States for 1913 would have been about 331,000,000 tons or about two third of the product actually won. If the bituminous mines had worked full 300 days in 1913 the production would have amounted to over 613,000,000 tons.

The total production of bituminous coal in the United States increased from 450,104,982 short tons in 1912 to 478,522,203 tons in 1913. The quantity of coal undercut or otherwise mined by the use of machines increased from 210,538,523 tons to 242,476,559 tons. The increase in the total production was 28,418,221 tons, or 6.3 per cent, and the increase in the output by the use of machines was 31,937,737 tons, or more than 15 per cent. The increase in the production of machine-mined coal exceeded the increase in the total production by 3,519,[illegible] tons. The percentage of machine-mined coal to the total output has increased each year since the first successful mining machines were installed. In 1903, ten years prior to the period covered by the present report, the quantity of bituminous coal mined by machinery in [illegible] represented 27.6 per cent of the total; [illegible] it was 51.7 per cent; in 1911, 43.9 per cent; in [illegible] and in 1913, 50.7 per cent. [illegible] there has been a general [illegible] of labor in the bituminous fields, a condition favorable to further advances in mining wages and to the more extended use of mining machinery to offset them. It is to be expected, therefore, that the production of coal by mechanical methods will continue to show proportionate increase until a relatively small quantity will be mined by hand. In addition to the economic and humanitarian results accomplished by the use of machines, another important end is attained. The larger the proportion of coal mined by machines the smaller will be the proportion of coal shot off the solid without having been previously mined or sheared. Any step which mitigates that evil in the mining of bituminous coal is a step in advance, and as shown in the section on mining methods in this report, there was a reduction in the percentage of coal mined by powder. Recent developments in the construction of mining machinery have provided machines which are adapted to beds of any inclination, so that there are now practically no insurmountable physical obstacles to the substitution of machines for hand labor.

The methods of attacking the coal by machinery are of two distinct types. One is that of sawing; the other, of chopping. Three types of machines represent the former method—the chain-breast, the long-wall, and the short-wall. In these machines the coal is attacked by bits attached to an endless chain or to the periphery of a disk, and, as can be readily seen, the action is very similar to that of sawing wood. In the second type of machine the coal is attacked by bits attached to arms actuated reciprocally, as in the action of drilling, except that the work of the drill is not confined to one hole, but is freely changed at the will of the operator. These machines are designated as the pick or puncher, in which the drill is mounted on two wheels and operated on a platform in front of the face of the coal, and as the radialaxe or post-puncher, in which the piston is attached to a post and drill is radiated in one plane. This latter machine has been developed for use in the steep-pitching beds. A new machine, brought out in 1912, combines the sawing and the chopping actions of the other two types. In this machine bits are inserted in the manner of a screw around an arm projecting from the machine. This arm is given both a reciprocating and a revolving motion, so that the coal is attacked by both a chopping and a sawing action. This machine was not actually placed on the market until 1913.

The total number of machines reported in use in the bituminous coal mines of the United States in 1913 was 16,381, an increase of 1,083 over 1912, when the number of machines reported was 15,298. The average number of tons mined by each machine in 1913 was 14,802, against 13,763 in 1912, the average for 1913 being the largest tonnage per machine reported. The best record prior to 1913 was in 1899, when the average production per machine was 14,068 tons. The most popular types of machines now in use are the pick or puncher and the chain-breast, the latter being in somewhat more general use in 1913; in 1912 the larger number of machines used were punchers. Out of the total of 16,381 machines in use in 1913, 6,986, or 42.3 per cent, were chain-breast; 6,327 were punchers; 2,210 were short-wall; 791 were long-wall; and 117 were of the radialaxe or post-puncher type. The rapid gain of the short-wall machine in popularity is referred to in the report for 1912, and it continued in 1913, the number of this type of machine having increased from 1,371 to 2,210, a gain of 839, or 60 per cent. Pennsylvania, the largest producer of bituminous coal, is also first in the total tonnage mined by machines and in the total number of machines in use. West Virginia, the second State in coal-producing importance, ranks also second in the number of machines in use and in the tonnage won by them; but the credit for the largest percentage of machine-mined coal to the total output belongs indisputably to Ohio, whose output of coal mined by machines in 1913 was 90.2 per cent of the total production. In 1912, 87 per cent of Ohio's production was machine mined. Kentucky ranks second in the percentage of the total product mined by machines with 73.2 per cent in 1913, against 66.4 per cent in 1912. Michigan's percentage of machine-mined coal increased from 52.7 per cent in 1912 to 70 per cent in 1913. West Virginia, Pennsylvania, and Indiana were each credited with more than half of their total production mined by machines in both years, and Illinois had 51 per cent in 1913, compared with 45 in 1912. In 1913 Pennsylvania's production of machine-mined coal was 92,487,438 short tons out of a total of 173,781,217 tons. West Virginia, with a total production of 71,308,962 tons, reported 39,410,264 tons mined by machines; Ohio, with a total production of 30,200,527 tons, reported 32,642,848 tons as mined by machines. Illinois's production of machine-mined coal was 32,630,555 out of a total of 61,618,744 tons; Indiana reported 9,737,425 tons as machine-mined out of a total production of 17,165,671. *Mineral Resources of the United States for 1913, Department of Interior, by E. W. Parker.*

A Motorcycle Street Sweeper

One of the latest American novelties is a motor cycle street sweeper, says the *Motor Cycle*. It is mounted on a sidecar chassis of peculiar design, and in front of the sweeping mechanism is a steel brush which acts as an agitator for the purpose of loosening the dirt, so that the broom will easily remove it. The broom is lowered by means of a handle situated on the left of the driver's seat and when the broom is in contact with the pavement it engages the actuating mechanism connected to the sidecar wheel, which causes the broom to rotate. Raising the broom throws the mechanism out of action. It is designed to be used on asphalt or wood-paved streets. At present one of these machines is in operation in Washington, and owing to its satisfactory operation its use is likely to be extended.

Ancient Wax Seals

Interesting results obtained by the Government chemist by making analyses of old wax impressions on documents in the Public Record Office are described by Mr. Ainsworth Mitchell in *Knowledge*. The seals examined dated from the thirteenth to the eighteenth century, and differed but little from modern sealing wax. Most of them consisted of a mixture of beeswax and resin, others of pure beeswax. Two seals, of the dates 1399 and 1423 respectively, were composed of wax, the characteristics of which agreed more nearly with those of East Indian than of European beeswax. The wax composing an impression from the Great Seal of 1350 agreed, in chemical and physical characters, with pure beeswax of to-day. The pigment in the red seals was vermilion, while the green seals contained verdigris.

A Stop Motion for Moving Picture Machines

An Ingenious and Radical Improvement

By W. B. Morton

Ever since intermittent movement has been in use particular efforts have been made to make the movement of such characteristic that the least amount of strain would bear on the part to be moved

In a continuous movement no force is required for the maintenance of the movement except to overcome incidental friction and windage

In an intermittent movement however considerable forces are required to accelerate the masses from standstill to maximum velocity and then again to retard the same masses from that maximum velocity to a standstill If the accelerating force is constant during the whole time of acceleration a uniformly accelerated movement ensues

The simplest form of such uniformly accelerated movement is given in that of a falling body whose velocity increases uniformly for successive time periods We know that the force producing this movement is never less than the weight of the body which remains constant from the time that it starts on its downward course It is therefore evident that if we design for a movement of the body of uniform acceleration that the force required to propel it must be constant It is immaterial in that respect whether the movement be a translatory, as in

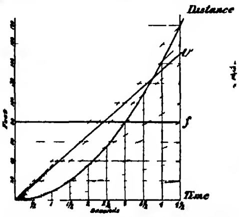


Fig 1—Diagram showing relation between distance traveled and time referred to a falling body.

the case with a falling body or whether the movement sought is an angular one

To enable us therefore to produce the intermittent movement with a minimum amount of force acting at any time on the masses it is important to design the cam in such way as to impart to the intermittent system an angular movement of uniform increment of velocity

An intermittent movement which does not work on this principle of uniform power application during all the time available must needs act in such way as to require a greater force during one period to offset the deficiency of force during the other period So that by deviating from the uniformly accelerated movement the maximum force required is greater than that uniform one which produces the movement of uniform acceleration In Fig 1 I have shown the well known relation between the distance traveled and the time referred to a falling body This curve is a parabola To ascertain the velocity at any moment, we have only to determine the increment of the movement per unit time or, expressed in other words, determine the differential quotient of this parabolic function at that moment Both the geometric qualities of the parabola as well as the mathematical expression for its function lead to velocities which lie on a straight line emanating from the center

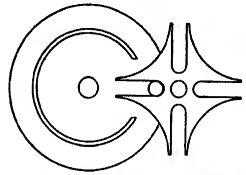


Fig 2—Four slot Geneva movement

of the co-ordinate system In the diagram Fig 1, this velocity line is marked v

In general the force required to produce velocity changes is given by the increment of the velocity, which in case of the straight velocity line v is a constant designated f in the diagram Fig 1 as the increment of the velocity line v is the same for all the points of the diagram

The object of the intermittent movement in a motion picture projecting machine is to advance the film in as short a period as possible with a minimum strain on the moving parts The requirement of quick movement is evident from the fact that during the movement the shutter has to obliterate any possible light on the screen and the longer the movement therefore the more the screen is deprived of useful light On the other hand the strain in moving parts has to be kept to a minimum to obviate undue vibration both of the machine and of

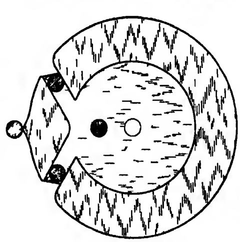


Fig 4—The Power cam.

the film and to minimise the wear on the delicate part of the machinery and on the sprocket holes in the film

It is deemed best to consider first the limitations of the intermittent movement generally known as Geneva movement

In the Geneva movement the time required is exactly one quarter of the turn of the pin wheel If the Geneva gear were made with five slots instead of four, as shown in Fig 2, the movement would require one fifth of the revolution of the pin wheel, or, as it is usually expressed, in the four-slot Geneva, the movement and therefore of the film, covers 90 degrees of the fly wheel, whereas in a five-slot Geneva, the movement and therefore of the film, is completed in 72 degrees of the fly wheel

With the five-slot Geneva, the movement of the film requires one fifth of the time and the film, while stationary, could transmit the picture during four fifths of the time With the four-slot Geneva, the film is moving during one fourth of the time and standing still three fourths of the time

While we could therefore shorten the percentual time of movement of the film from 25 per cent in the four-slot Geneva to 20 per cent in the five-slot Geneva, no means are possible by which to make a change anywhere between these two figures

The four-slot Geneva, being universally adopted precludes therefore the possibility of designing the machine for any other ratio of movement to rest, or darkness to light-transmission than one to three

In Fig 3, the horizontal line denotes time, whereas the vertical lines may denote movement of the film For the Geneva the movement is given by line G, which shows that from the beginning of engagement of the pin in the slot, the increase of the velocity of the film is extremely small great increase in velocity, however occurs at the point marked h At the point s the velocity of the film has reached the maximum, and from there on decreases in velocity more rapidly during a short period j, and finally comes to zero on position plus 45

It will be seen that the work of the Geneva is done almost entirely in the two short periods h and j, whereas little power is transmitted at the beginning or at the middle of the movement The total strain of acceleration and the retardation of the film is therefore concentrated at two comparatively short periods of the whole time of movement and the wear of the Geneva slot and

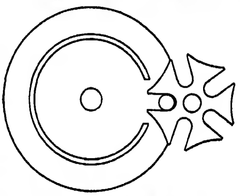


Fig 7—Five slot Geneva movement.

pin as well as the intermittent sprocket s teeth and film holes becomes excessive

To avoid such uneven and excessive force both in the Geneva itself and on the film, Mr Nicholas Power designed the cam movement, shown in Fig 4

This movement is not limited to any particular percentage for the movement of the film the cam being designed for any number of degrees desired The velocity of the film is diagrammatically shown in Fig 5 which shows in comparison to Fig 3 that the initial time of movement m is utilized to better advantage for accelerating the film and thereby relieving the part h of the diagram 3 of its excessive rise

Such even distribution of power transmitted from the fly wheel to the intermittent and from the sprocket to the film, accomplishes the total movement of the film of ¾ inch at a shorter time equal to 71 degrees of the fly wheel with a strain on the film, which can be gaged by the comparison of steepness of the angle a as against the angle A

To facilitate this comparison, Fig 6 is shown wherein the movement as well as the forces required are shown

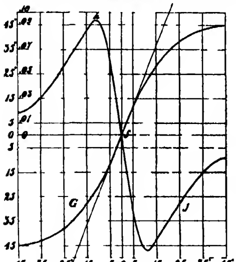


Fig 3—Movement of film in relation to Geneva stop movement

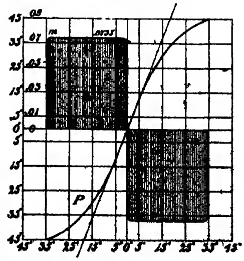


Fig. 5.—Movement of film as controlled by the new Power cam movement.

relating to those of the Geneva and the Power cam

Mr Power has therefore combined in this one design three changes of mechanical operations

1 Shorter time of movement (71 degrees as against 90 degrees)

2 Uniform distribution of strain over the whole period of movement as against the unevenly divided action of the Geneva

3 Reduction in the engagement force from which three noticeable deserts are given in the operation

1st More light
2d Less vibration
3d Less wear both on the intermittent movement intermittent sprocket and film

An argument might be advanced that as above men-

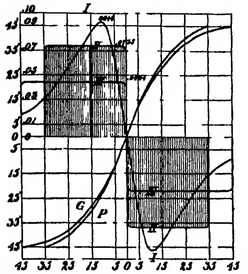


Fig 6—Comparison of movement and forces required by Geneva and Power movements

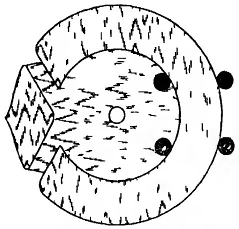


Fig 8—Another view of Power cam

tioned the Power cam shows more force transmitted during the initial part of the engagement than the Geneva movement and in starting and therefore less destructive for the film at least during this period of the engagement

A rope will hardly last longer by being given plenty of rest mornings and evenings but being overstrained beyond its safe capacity to a full day s work during the few hours of a day

The work that the Geneva is not doing in the beginning of the movement it has to make up during the short periods k and j causing jerks and running the film sprocket wheel and the slot and pin

Comparing first the maximum force required for the Geneva with that of a Power cam of 90 degrees movement as given in III we see that the latter requires a force which is less than one half of that required for the Geneva the two absolute values being 0 44 as against 0 944

Such great superiority of the Power cam enables us, therefore to reduce the time for its action and still remain with its actuating force below that of a Geneva

Such case has been shown in Fig 6 by force line II which corresponds to the cam as incorporated in the projection machines manufactured There the time has been reduced from an angle of 90 degrees to only 70 degrees thereby reducing the dark period It is true that by such quicker action the actuating force increases but as seen from line II it is still far below the force required of the Geneva the relative values being 0 735 against 0 944

This comparison in Fig 6 between the force line of the Geneva (I) and the Power cam as used (II shows clearly the latter s advantage in reducing the time in a ratio of 70 degrees as against 90 degrees and reducing the actuating force in a ratio of 0 735 to 0 944

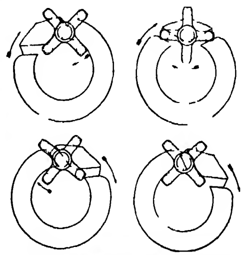


Fig 9—Diagrams illustrating operation of the Power cam

Unit Coal*

Attention is called to the heat values for the unit coal the pure substance free from ash moisture sulphur and other minor impurities This value like the coal bed moisture may be regarded as the normal factor for the actual coal and does not vary in a given mine from year to year If for example the average unit value for a given mine is 14 750 British thermal units per pound of this material any sample with whatever content of ash or moisture when calculated to this unit coal basis will give the same average value within the range of experimental error or about 100 units in 14 000 a variation of less than 1 per cent This value enables us to check the correctness of the various determinations any one of which if seriously in error would vitiate the result Conversely by reversing the calculation we are enabled to obtain a close estimate of the heat value present for any given percentage of ash This is of special value where it is desired to submit a bid for contracting in which a guaranteed heat value is to be indicated The formula by which this value is derived is as follows

$$\text{Unit B t u} = \frac{\text{Dry B t u} - 5000S}{1\,00 - (1\,08A + 558)}$$

In which A is the weight of ash per gramme
S is the weight of sulphur per gramme

If every mine operator were to obtain as often as possible this unit value for his product he could very shortly derive from an average of his log of values, a basic factor which would be of great advantage to him in submitting propositions for coal supplies

A special survey was recently made of certain mines in the five counties named in Illinois The average of the 'unit-coal values for each mine may be taken as a constant for the output of that mine

AVERAGE HEAT VALUE FOR UNIT COAL[1] IN BRITISH THERMAL UNITS PER POUND

No	County	Coal bed	Number of samples averaged	Average—B t u unit coal
1	Sangamon	5	15	14 424
2	Sangamon	6	5	14 340
3	Macoupin	6	6	14 310
4	Madison	6	18	14 350
5	Vermilion	6	19	14 597
6	Vermilion.	7	9	14 780
7	Williamson	6	5	14 750

The use which can be made of these unit" values such as are shown in this table may be readily understood when it is remembered that each number represents material which is 100 per cent pure and that for each per cent of inert matter present such as water and ash there is a corresponding decrease in the number of heat units present. That is to say if a coal has 20 per cent water and ash, then 80 per cent of the unit value will represent the heat units present per pound of coal as delivered Indeed it is possible by taking account of certain refinements such as correction factors for sulphur and hydration of the shaly constituents to make a calculation which will be of quite sufficient accuracy for basing bids and entering into contracts involving a guarantee as to heat values The method of calculation is exceedingly simple and is based on the following expression

Let A weight of ash per pound of coal
Let b — weight of sulphur per pound of coal
Then—

Dry B t u = Unit B t u × 1 00 — (1 08A + 0 55S

To illustrate take the unit' value for coal from Vermilion County sample No 6 in the table Suppose we wish to know what heat values can be guaranteed on deliveries from a mine of this group on the basis that we can furnish material averaging as the dry coal 12 per cent ash, and 3 per cent sulphur we will have our total non combustible material corrected by the above formula as follows

	Per cent
1 08A	12 96
0 55S	1 65
Total	14 61

100% — 14 61% = 85 39%
14730 × 85 39% = 12578

In this calculation the sulphur has been neglected It has a small heat value equal to 5 000 times the weight of sulphur present or 50 times the percentage number thus

50 × 3 = 150 units to be added to the above value or

12578
150
12728 B t u

Deliveries from this mine therefore having ash, and sulphur as indicated above can be depended upon as carrying 12728 heat units per pound of dry' coal and this factor should be accurate within 100 units in 12 000 or less than a variation of 1 per cent from values as they would be determined by direct reading from an instrument Any other set of values for ash and sulphur would similarly admit of ready calculation and should be used as a basis for calculations involving guarantees of deliveries on a heat-unit basis If the heat units on the "wet" coal basis are desired assuming for example a moisture factor of 15 per cent the above value as derived for dry coal should be multiplied by 0 85 that is 12728 B t u × 0 85 = 10818 B t u per pound of the wet coal assuming a moisture factor of 15 per cent as indicated In this connection attention should be given to the assumed values which it is proposed to maintain for water and ash

* Bulletin 29, Illinois State Geological Survey, by S. W Parr.

[1] Illinois State Geological Survey, Bull. 16, p. 212, 1909

[2] Pillar and storage coal will have heat units from 1 per cent to 4 per cent below the values here given

Lightning Rods

Even to day really few people understand what occurs when there is a flash of lightning or the part played by the lightning rod Some very interesting and valuable information on these matters and on the protective range of lightning rods is given by J and J S B Larmor in the Proceedings of the Royal Society Among other things they say Electric discharge in a gas is a rupture it is a line of force and not over a surface The initial rupture is to be expected at a place of maximum force and spreads in both directions along the line of force through that point In the case of a lightning rod the discharge would start at the summit of the rod the place of most intense strain and strike away from the rod Once a line of disruptive discharge is established the neighborhood of a lightning rod can have little effect and a simple mathematical investigation shows that a thin isolated rod will draw the discharge hardly at all unless in the region around its summit and that the modification in the field due to a thin rod is negligible along its sides unless close to it It is the building carrying the rod which modifies the field and directs discharge to its own upper parts which therefore need protection by conductors adequate to draw off this discharge to earth and vertical rods joining together if need be lower down but rising from the corners of the structure to a height which need not exceed about half its breadth will lift up the field of concentrated electric force from the region directly above the building to the region above their summits and will so take the discharge The rods may rise from an earth-connected network spread over the roof but unless the meshes are fine enough to approximate to a complete metallic covering it is questionable whether it would in itself protect a building from a discharge striking down upon it A spread of connected metallic points some height above the building would appear to be more effective and might even by themselves suffice to take up and guide away any likely stroke In fact if we neglect the discharge from the rods into the field their effect is merely to provide the easiest and most probable path for such discharges as may be attracted by the structure The discharge from the pointed extremities of the rods adds of course to the protective effect by slowly but continuously reducing the strain in their neighborhood and therefore the liability to disruptive discharge

Electrometallurgy—II*

Modern Methods of Producing and Refining Various Metals

By Joseph W. Richards

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2058, Page 379, June 12, 1915

WE will next consider the question of the "fused salts." In nature we find a number of metals in the state of salts which are fusible and which can be electrolyzed—sodium, calcium, and magnesium are obtained directly by the electrolyzation of those simple salts. Common salt, for instance, is only worth a few dollars a ton. If converted into metallic sodium on the one hand and chlorine gas on the other, one worth several hundred dollars per ton, and the other worth fifty dollars a ton, you can see there is a great economic gain. The value of the product is out of all proportion to the cost of the raw material, and the cheapest way to do it is electrolytically. We have, therefore, numerous sodium works manufacturing sodium and chlorine from sodium chloride. Sodium fluoride is a stronger salt than sodium chloride, and if mixed with the latter is not decomposed by the current, because it is a weaker salt. The sodium fluoride keeps the melting-point of the bath down, and enables them to work it at a lower temperature, and thus get a better return of sodium. The uses for sodium increase greatly as the price goes down. Up to a couple of years ago sodium makers were using caustic soda (NaOH), costing about forty dollars a ton. That was costly, and increased the price of the sodium; but by going back to the original sodium chloride, and finding electrolytic methods by which it could be utilized, the cost of the metal has considerably decreased.

Calcium chloride occurs to a small extent in nature, but should properly be classed as an artificial salt. We have here an interesting illustration of another method of electrolyzing a fused salt. The bath consists of the fused calcium chloride. Calcium is so light that it floats to the surface of the bath, and when it floats it is exposed to the air, and is apt to take fire. By putting the cathode just in contact with the upper surface of the electrolyte, the button is deposited against the electrode, and when it reaches a given size the electrode is lifted a bit. The fused salt sets on it and protects it from the air. By continuing to slowly raise the electrode, there is obtained an irregular rod of the metal. You buy the metallic calcium in a stick about one and one-half inches in diameter, just as it is drawn away from the surface of the electrolyte. Metallic magnesium is made in a similar way. With a specific gravity of 1.721 it floats to the surface. I have never seen any made in that way, but I hear that the same firm that makes calcium makes metallic magnesium in the same way.

Cerium is used for Welsbach gas mantles, which contain thorium and cerium oxide. The residue from this manufacture is piled up high in the Welsbach Company's yards at Gloucester. It is about half cerium oxide. Dr. Auer von Welsbach started to see if he could not utilize this residue, and he began by studying the properties of metallic cerium to see what useful properties it might have. He was impressed by the striking property which it has of giving sparks, and found by experiment that by alloying it with iron he could greatly increase the spark-giving property so as to make it useful in those little cigar-lighters with which we are all familiar. The alloy used in those lighters is made from the waste cerium oxides dissolved in fused fluorides. It is put into an electrolytic bath, in somewhat the same manner as a chloride. The other rare metals (lanthanum, didymium) are allowed to stay in because they do not injure the quality of the alloy. There is no works manufacturing cerium at the present time in this country; but I visited such works at Treibach, in Austria, last year, and I understand that Dr. Fattinger has been over here considering where to put up a plant to manufacture these alloys from the residues which are in the yards at Gloucester, N. J. This industry employs three or four thousand workmen in Austria, and there is no reason why we should not have a similar industry over here.

I mention zinc here because a great deal of money has been spent in trying to manufacture zinc chloride and then to electrolyze it. The idea is to treat those complex sulphide ores which contain zinc with chlorine gas, converting the zinc into chloride, separating it from the other chlorides, purifying it, and the forming of it a bath, electrolysing it and getting back the chlorine, which is used again in the early part of the process. The ores are so complex that the operation has not yet been made a commercial success.

Electrolysis of solutions in fused baths is a principle which was discovered by Mr. Charles M. Hall, and has been the foundation of the whole aluminum industry. It costs considerable money to get pure aluminum; but if you do not get it pure it is useless for many purposes. Mr. Hall was trying to decompose alumina (Al_2O_3) electrically, and he conceived the idea that if he could find some fused salt which would dissolve it the problem might be solved. Cryolite from Greenland is used for that purpose. It looks like wax or ice; its name "cryolite," means "ice-stone." It fuses at 1,000 deg. Cent., and when fused it is as limpid or clear as distilled water. Alumina dissolves in it like sugar in water. Take such a solution, put electrodes in, pass the current through, and you get out aluminium. You have to replenish the alumina as the supply in the bath becomes depleted. This invention of Mr. Hall is the corner-stone of the whole aluminium industry. There is probably 150,000 horse-power being used to manufacture aluminium. The output last year was something like 65,000 metric tons, of which about 40,000 were manufactured in America. The extent of this infant industry is amazing; it replaces three to four times its weight of the metals with which it is competing, because of its very low specific gravity. The output of copper in this country is now about 500,000 tons a year, and is nearly stationary; while the output of aluminium, starting with almost nothing, has been doubling nearly every year. Last year, including Canada, the American output was estimated at 69,000,000 pounds. The commercial importance of this should appeal to us. I believe that aluminium is going to give copper a hard race. There is considerably more margin for reducing the cost of aluminium and selling it at a lower price than there is for copper. When copper gets below eleven cents a pound, many mines have to stop producing; but aluminium can be sold at a profit at a price lower than the cost of one equivalent amount of copper.

We now come to the electro-thermal methods and electric furnaces. The electric furnace was first used to fuse metals. There are different kinds of electric furnaces; you can class them broadly into resistance furnaces and arc furnaces. Resistance furnaces can be subdivided into the direct-resistance furnace and the induction furnace. The direct-resistance furnace is one in which the material is heated directly by the passage of the current through it, while in the induction furnace it is heated by an induced current. In the arc furnace, where you use the arc, there is also some heat generated by the resistance of the electrodes, and some by the passage of current in the materials, where the arc jumps to the materials. The resistance of the arc, however, will account for 75 to 90 per cent of the heat generated.

The fusion of metals was first tried by Siemens in England. He used a little crucible, making the bottom of his crucible one electrode of his furnace, and the other terminal an electrode entering from above. He published his paper before the Institute of Telegraphic Engineers in England, because he could find no other scientific society interested in it. He rigged up a little automatic regulator to keep the arc constant, and his idea was to melt steel directly in the crucible, a crucibleful at a time, by electric heat. In some of his tests he obtained about 50 per cent thermal efficiency for the purpose desired—i. e., the heat in the melted steel was some 50 per cent of the heat-equivalent of the electrolytic energy used. His furnace never went into commercial use; but it was followed some twenty years later by the furnace of Mr. Heroult in the Savoy, France, who was the first to have the idea of fusing steel in a large furnace. Girod also constructed a practicable steel-melting electric furnace, and there are several forms of successful induction furnaces. Within the next five years Mr. Hering's resistance furnace will also be making steel. Electric-furnace steel is rapidly replacing crucible steel; it will probably replace it entirely in the next ten years. All steel could be benefited by a short sojourn in the electric furnace, and the latter will come into large use as an adjunct to the open-hearth steel furnace and the Bessemer converter.

Mr. Hering's resistance furnace uses small pencil-shaped resistors, filled with molten metal, and transfers the heat generated in them to the molten metal bath. The circulation in and out of these resistors is so active, because of the "pinch" force and its attendant "squirt" effect, that their temperature does not get excessive, and the heat generated in them is rapidly transferred to the main bath. I have seen this furnace working very prettily on brass and cast iron, and I believe it has as promising a future as any electric furnace.

The Stassano furnace is a typical arc radiation furnace. It is usually run by three-phase current, the three arcs being kept clear of the bath of metal, which is heated by direct radiation from the arc or indirect radiation from the roof. The three electrodes are a little above the surface of the bath, at equal angular distances and with an arc springing between them. But in practice the arc may easily pass to the bath because of the metallic vapors produced in an intense heat like that. The air in the furnace becomes quite conductive from silicon, manganese, and iron vapors, so that you can have a 6 inch arc with about 90 volts across the phases; it is similar to a mercury arc.

The induction-furnaces, of which there are several variations and types, are a great triumph of metallurgical and engineering art. I have the greatest respect for the man who first built a furnace like a transformer, with only one secondary turn, put a primary right in the center of that ring, and succeeded in keeping it cool enough so that it did not melt the insulation on the wire, and transmitting the magnetic flux through the intervening space and materials to the metal which was to be melted. I regard the induction-furnace as a marvel of engineering construction, and it was fortunate that it has been taken up by the Germans. It was first worked commercially in Sweden, but was devised years before by Mr. Colby, of Newark, N. J., who tried it, but did not make it a commercial success. Mr. Kjellin, in Gysinge, Sweden, did it commercially, and then the Germans took hold of it, and stuck to it, improved it, and with their great tenacity have overcome the difficulties and made the induction-furnace better than I think any other nation could have made it. Many have thought that the induction-furnace would drop out of the race, but the German is coming along with some further improvements all the time. It is better adapted for melting and keeping steel melted than for refining the steel. It is not very well adapted for refining the steel because of the limited surface exposed. The Germans, however, are overcoming even that difficulty, and have arranged a large open bath in the center of their furnace, a bath in the middle, where there is room for the action of the chemicals on the steel for refining it.

Mr. Paul Heroult was the first one to melt steel commercially in an electric furnace. He was not a steelmaker; he was an electrical engineer, and he used to say, "I do not know anything about steel, but I am going to learn." I think he succeeded by learning some short cuts. You know we frequently are handicapped by knowing too much about a thing. He made a new flux, and used the arc; he used it "without knowing that some things could not be done," and he did them. His furnace was nothing more nor less in outline than an open-hearth furnace. His idea was to build a tilting open-hearth furnace, and to put his two electrodes through the roof above the bath. The idea of putting two arcs in series, with the bath as an intermediate conductor, was novel. Heroult patented the idea of melting steel by two electrodes in an electric furnace, passing the two arcs through a layer of silica slag. Mr. Heroult's furnace has been improved upon or modified by Mr. Girod, who uses only one upper electrode and conducts the lower electrode through the hearth of the furnace, so that he has only one arc, and takes off the current through the one electrode running through the hearth of the furnace. These electrodes in action are partly melted, about half-way down, and the rest is solid. They are quite successful; I have seen some of them which [illegible]. The steel metallurgist would be the last to dare to make a hole in the hearth of his furnace, and put an electrode through the bottom. But this was where the electrical engineer put it, and there has been no trouble whatever with these electrodes. [illegible] the electrical engineer put them would have been the last place the metallurgist would put them.

* A paper read before the Engineers' Club of Philadelphia, U. S. A.

Concerning the reduction of compounds to metal in electric furnaces, I have time to pick out only a few characteristic examples:

Boron is one of the rarest metals, but its compounds are abundant. It is made by bringing a volatile boron salt with hydrogen gas into an electric arc, where they are heated to a very high temperature. The salt is reduced by the hydrogen to metal, and the vapors produced are chilled before they have a chance to recombine. It is the same operating principle as is used in the fixation of atmospheric nitrogen in Norway. This boron is being put on the market for use in casting "conductivity" copper. This is one of the most recent productions of the electric furnace.

In Niagara Falls, Mr. Tone is reducing ordinary silica sand, SiO_2, to metallic silicon. This gentleman once took me into the carborundum works at Niagara, showed me a barrel containing something, and told me to guess what it was. I made two or three vain guesses, and he finally told me that it was silicon, which, he said, "we can make for a few cents a pound." At that time metallic silicon was quoted in commercial price-lists at \$4 a gramme (\$18 a pound). He said he wanted to find some use for it. Silicon is somewhat volatile, and 25 per cent of that which he puts into his furnace goes up in smoke. He is now making silicon at Niagara Falls by the ton. Silica is mixed with carbon, put into a furnace heated by a carbon resistor, the mixture of silica and carbon being piled around the resistor, and the metal filters down around this resistor and runs out something like slag. It is being cast into vessels for use in chemical works. Thus is the most abundant element on earth now commercially available at a price of about six or seven cents a pound. One can only speculate as to the future uses of it; it is made from the cheapest materials; the reducing agent is cheap carbon; and you have metallic silica from the electric furnace.

The zinc industry is attracting a great deal of attention. It is, apparently, one of the least progressive of the metallurgical industries. Little bits of retorts are heated to a high temperature, a few shovelsful of roasted ore mixed with carbon are put into each retort and left there for 24 hours. Everything is done in a very homœopathic way, and yet it is so difficult a metal to handle that it is only by holding fast the ground gained that it has reached its present status. The electric furnace zinc industry has been made successful in Europe; there are works in profitable operation in Norway, Sweden, and Finland, while much skilful experimenting has been done in America. Last year 4,000 horse-power was being used in producing zinc in Scandanavia, and 7,000 horse-power has been added since then. The firms are very reticent about their methods; in fact, there is no reliable published data about their present type of furnace.

The manufacture of ferro-manganese, ferro-tungsten, etc., for making special steels, is done almost entirely in the electric furnace. The oxide of iron is mixed with the oxide of the metal to be reduced, with sufficient carbon for reduction. It takes about half a horse-power year to produce a ton of 50 per cent ferro-silicon, for instance. The chief seat of this industry is the Savoy, in France, but the industry is gaining ground in the United States and Canada, and imports are decreasing. Stassano, in Turin, was the first to make such alloys, using his arc-radiation furnace, but enormous furnaces (Helfenstein's) of 5,000 to 10,000 horse-power are now used in this industry, which thus led up to the electric furnace manufacture of pig-iron and pig-steel.

The manufacture of the cheapest metal we have from the cheapest ore we have by electrometallurgical process is, I suppose, one of the greatest triumphs of electrometallurgy. The electric current can really be used for doing what is now done in the blast, and it is possible under some circumstances to replace it by an electrometallurgical furnace; that is the last triumph of electrometallurgy.

In one little place in Sweden that I visited two years ago, charcoal was getting scarce, and they were importing coke from England to run their blast-furnaces, and the quality of the product was not that of iron made with charcoal. They were much interested in the electric furnace, because it requires only one-third as much fuel to make a ton of pig-iron as the blast-furnace. In their blast-furnaces, with the charcoal available, they could make 300,000 tons of pig-iron, but in the electric furnace they could make 900,000 tons with the same fuel; so that was one of the inducements to use the electric furnace. The Swedes spent a quarter of a million dollars before they had a successful working furnace. They did their work in a most scientific way all through, watched their temperatures and all the conditions, and knew exactly what they were doing all the time. As a net result, they made pig-iron in the electric furnace as cheaply as they can in their blast-furnaces. The Jern Kontoret (Iron Masters' Society) bought the patents for the furnaces, so that they became the common property of all the ironmasters of Sweden, and they have been putting up furnaces pretty rapidly. The last one was designed for 12,000 horse-power. It has been running for nearly a year at from 6,000 horse-power to 8,000 horse-power, making 56 tons of pig-iron per day. If it were run at full capacity, I think they could make 100 tons a day, which is equal to the average capacity of one of their blast-furnaces.

At Domnarfvet and Hagfors, in Sweden, the same thing is pending. At the latter works they calculate that with this large furnace there is a margin of \$2.50 per ton on the cost of pig-iron, to the advantage of the electrical furnace over their blast-furnaces, so that electric furnace pig-iron is being made at a profit and cheaper than it could be made in the blast-furnace in Sweden.

The possibility of making a product from this furnace which is not pig-iron, but which, as far as carbon content is concerned, will have to be classed as steel, has been proved. That product, with less than two per cent of carbon, is in reality impure steel, and not cast iron. It requires only a small amount of refining to bring it to pure steel. With the excess of iron ore present in the furnace you can make a low-carbon product. With electricity to furnish the heat, you can regulate the carbon so as to make a product with only two per cent of carbon. This is a possibility with an electric furnace; but it is not a possibility with the blast-furnace. We can thus make pig-steel, with less than two per cent carbon, which can be converted in the open-hearth furnace into pure steel in about half the time that the ordinary product of the blast-furnace takes. This will bring advantages with which the blast-furnace cannot possibly compete. In the case of the problem being worked out, pig-steel will replace pig-iron for the manufacture of steel; this opens up the possibility of the electric reduction of iron ore going into use in places where otherwise it would not go if the product were simply pig-iron. It may come into Canada or along our northern borders, where water-power can be obtained cheaply, for there is the large expenditure of 3,000 horse-power hours per ton of product to be reckoned with. This will be the next great advance in the electrometallurgy of iron and steel.

Artificial Production of Caoutchouc*

Considerations of Synthetic Production of an Elastic Colloidal Substance

By F. Willy Hinrichsen, of the Koenigliches National-Pruefungsamt, Berlin[1]

The question of the artificial production of rubber is a problem of the greatest commercial and scientific importance. The "synthetic rubber phantom" which for some time past greatly agitated the planters and all interested in the collection of wild and plantation rubber, is still so present in the memory of all, that it hardly seems necessary to dwell here upon the commercial importance of rubber synthesis. On the other hand, from a purely scientific viewpoint there was presented the problem of preparing for the first time, synthetically, a typical colloidal substance and to discover relations between chemical constitution and elastic properties. It is therefore evident that the above problem was eagerly approached from various angles of science and technology. While I am here giving a short review of the present state of this subject I must at the same time limit myself to several essential main points. Complete consideration of the subject is, of course, out of the question, since only a small portion of the work accomplished in the technical laboratories on this subject is made publicly available. After Harries[2], in his pioneer work of 1905, established that the chemical constitution of natural caoutchouc $C_{10}H_{16}$ as a 1,5-dimethyl-cyklooctadien of the formula

CH₃.C–CH₂.CH₂.CH
CH.CH₂.CH₂.C–CH₃,

it was easier to approach the synthesis of the interesting hydrocarbon from the basis of the newly discovered knowledge. Several earlier observations had been made. Thus, Bouchardat[3] had found that the hydrocarbon isoprene, C_5H_8, resulting from the dry distillation of caoutchouc, and which had been previously discovered by Williams,[4] was a colorless liquid which boiled easily and which could be converted into a rubber-like substance by polymerization in the presence of aqueous hydrochloric acid. Tilden[5] had also found that, in the same way, isoprene which, in addition to being formed from caoutchouc, is produced by passing oil of turpentine through red hot tubes, was converted by hydrochloric acid or nitrosylchlorid into caoutchouc. However, as in spite of many repetitions under varying conditions of experimentation by other investigators, and even by Tilden himself, it was no longer possible to obtain the same result; it was assumed that only a purely accidental observation had been made, and that the material obtained, which in the state of science then existing, could not be determined to be caoutchouc, was not really a caoutchouc and that the statements of Bouchardat and Tilden were based on errors.

As a result of the enormous increases of the prices of rubber during the last few years and also because of the zealous scientific attention to the caoutchouc problem, particularly by Harries, the attention of a large circle of people, particularly in the industries, was drawn to the problem of the synthetic production of caoutchouc. The result was, that Fritz Hofmann and Carl Coutelle,[6] chemists of the Elberfeld Farbenfabriken vorm. Bayer & Co., succeeded in 1909 in converting absolutely pure isoprene, which they obtained by a new method, into caoutchouc, by simply heating it in a closed tube, either by itself or in the presence of certain other substances. A sample of this caoutchouc was sent to Harries, who proved with certainty by chemical tests that in this case caoutchouc actually resulted. Since the process by which Hofmann and Coutelle worked was not yet known, Harries also took up the experiments on the conversion of isoprene into caoutchouc, and in March 1910 he reported in a lecture in Vienna[7] on his observations, stating that it is possible to convert isoprene into caoutchouc by heating it in a closed tube in the presence of glacial acetic acid. Harries deserves the credit for being the first to publish a process which could be repeated, for converting isoprene into caoutchouc.

After the ball had once been started rolling investigations were also begun by others attacking the problem. Particular credit should also be accorded especially in the technical interpretation of the problem in addition to the Elberfeld Farbenfabriken, to numerous individual native and foreign investigators, and of industrial establishments, the Badische Anilin und Sodafabrik of Ludwigshafen.

Even in the original patent specifications of the Elberfeld Farbenfabriken the raw material was not limited to isoprene, but a series of hydrocarbons of related constitution was included in the scope of the observation. Isoprene itself has the formula

CH₂:C.CH:CH₂.
    |
   CH₃

It contains two neighboring double bonds, a so-called system of "conjugated double bonds." Other compounds with conjugated double bonds, as was recognized by Hofmann and Coutelle from the start, also possessed as does isoprene the same property of polymerizing into caoutchouc-like substances. Among these we have for example, erythrene, C_4H_6: $CH_2{:}CH.CH{:}CH_2$; further dimethylbutadiene, C_6H_{10}:

CH₂:C—C:CH₂
    | |
   CH₃ CH₃ ,

and many other similarly constructed substances.

Aside from the fact that because of the varied natures of the raw materials there was possibility of obtaining a whole series of different caoutchoucs, which of course must differ from each other because of their chemical

* [illegible], 1914, vol. 40, p. 16.

[1] [illegible] Hinrichsen and Memmler: Der Kautschuk und seine [illegible], published by S. Hirzel, Leipzig 1910, pp. 20 et seq. [illegible] published by Th. Steinkopff, [illegible] 1911.

[2] [illegible], vol. 37, p. 2,708; 1905, vol. 38, p. 1,195.

[3] [illegible] 1875, vol. 80, p. 1,450; 1879, vol. 89, p. 1,117.

[4] Proc. Royal Soc., London, 1860, vol. 10, p. 516.

[5] Chem. News, 1882, vol. 46, p. 120.

[6] German Patent Applications F. 26,950. Class 39b Group 1. September 11th, 1909. German patent 250,690, September 30th, 1909. German Patent 255,129, December 30th, 1909.

[7] Gummi Ztg., 1910, vol. 24, p. 850.

constitution, it was also noticed that the process of polymerization itself was susceptible of variation and that caoutchoucs prepared in various ways from the same raw material would differ from each other.

Harries[8], and independently of him the English investigators Mathews and Strange[9], simultaneously observed that the polymerization in the presence of metallic sodium took place with great velocity, but that the caoutchouc obtained was different from that obtained by heating alone. Furthermore, the chemists of the Badische Anilin und Sodafabrik found that the results were different when the polymerization with sodium was carried out in a carbon dioxid atmosphere. Another process which was developed in the Badische Anilin und Sodafabrik depends on the use of ozonids or peroxids as catalyzers.

According to the kind of raw material and the method of polymerising, rubbers are obtained which vary from one another totally in their properties. The following summary gives, according to Holt's[10] statements, a brief review of a series of such varying caoutchouc-like substances.

	CAOUTCHOUCS FROM BUTADIENE, C_4H_6.		
Normal caoutchouc (by heating): easily soluble, elastic, vulcanizable.	Ozonid caoutchouc: insoluble, swells up greatly, very elastic, unvulcanizable.	Carbon dioxid caoutchouc: insoluble, does not swell up, moderately elastic, unvulcanizable.	Sodium caoutchouc: easily soluble, elastic, vulcanizable.
	CAOUTCHOUCS FROM ISOPRENE, C_5H_8.		
Normal caoutchouc: easily soluble, elastic, vulcanizable.	Ozonid caoutchouc: swells up greatly, only soluble after rolling, elastic, vulcanizable.	Carbon dioxid caoutchouc: insoluble, does not swell up, elastic, vulcanizable.	Sodium caoutchouc: easily soluble, not elastic, difficultly and incompletely vulcanizable.
	CAOUTCHOUCS FROM DIMETHYLBUTADIENE, C_6H_{10}.		
Normal caoutchouc: easily soluble, not elastic, can only be vulcanized to hard rubber.	Ozonid caoutchouc: swells up, only soluble after rolling, not elastic, can only be vulcanized to hard rubber.	Carbon dioxid caoutchouc: insoluble, does not swell up, not elastic, difficultly vulcanizable, easily oxidizable.	Sodium caoutchouc: soluble and insoluble modification, not elastic, unvulcanizable.

The scientific significance of the above-mentioned facts is obvious. It was the first time that elastic colloidal materials were synthetically prepared. The possibility of obtaining materials having changing properties by changing the raw material and the polymerization process, that is, by choice of the experimentation conditions, led to the hope that it must be possible, as in the field of dyestuffs and odoriferous substances, arbitrarily to obtain materials of definite properties by means of slight changes which would be particularly suitable for definite purposes. Just as we are able, in the case of dyestuffs to change the tone of the dyestuff at will by the addition of certain groups, etc., so it should also be possible in a similar way to arbitrarily change the elastic and solidity qualities of caoutchouc.

It is entirely different as regards the economic importance of the synthesis of caoutchouc. Should artificial rubber become a serious rival of natural rubber it must equal it in two respects: price and technical adaptability. It is not necessary, however, to conceive of the complete replacement of natural rubber by artificial, as in the case of indigo, alizarin, etc.

As regards the price of synthetic caoutchouc, this is first of all governed by the cost of preparing the hydrocarbons of the isoprene series which serve as the raw materials. In this respect great progress has undoubtedly been made in the most recent times. A process of the Badische Anilin und Sodafabrik which depends on certain fractions of petroleum seems to promise special success.

Additional raw materials are among others, starch, amyl alcohol, oil of turpentine, acetylene, etc. In spite of the great pains that have been taken in order to increase the yields of the various processes, it must be said that the desired goal has not yet been reached. As regards the price of a serious competition of the artificial with plantation rubber is not yet to be thought of. In addition also the amount of oil of turpentine which would be required, is limited and its price would soar with an increasing demand. In order to secure the starch necessary for the world's demand of rubber, which already amounts to more than 100,000 metric tons yearly, fields of corn or potatoes would have to be planted, the extent of which would have to very greatly exceed that of the present rubber plantations. From all these processes there will result such large quantities of by-products, that their removal would give rise to even more difficult problems than that of producing the caoutchouc itself.[11]

Even in spite of the last named difficulties the question of price would not be the controlling one if the previously mentioned objects were accomplished and if it were possible to produce by the proper choice of working conditions caoutchouc-like materials specially adapted for certain purposes. It can be imagined that certain synthetic caoutchoucs designed for definite purposes, embodying a combination of certain favorable properties may surpass natural caoutchouc and may be sold at a higher price. This has not yet been achieved.

No sufficient technical data have yet been made public regarding the technical adaptability of synthetic caoutchouc. As far as known observations on this subject go, it is evident that synthetic caoutchouc has not approached the properties, especially the stability of natural rubber. The reason for this may be readily seen. Natural rubber, because of its vegetable origin, contains a series of accompanying substances, for example resin, albuminoids, etc., which must certainly influence its stability. For 'tis known that de-resinified caoutchouc is far more readily attacked by the oxygen of the air than caoutchouc containing resin. It is possible that the accompanying substances act as protective colloids which lessen the sensibility of the pure material, in a way similar to, for example, the prevention of precipitation of gold, colloidally dissolved, by the presence of certain protective colloids.

Another reason for the fact that synthetic caoutchoucs in their mechanical properties are not the equal of the natural caoutchouc may be looked for in the fact, according to Steimmig's[12] recent investigations, that in contrast with natural caoutchouc, most synthetic caoutchoucs are not uniform compounds but mixtures. As Steimmig found, during the oxidative splitting up of synthetic caoutchouc, there result in addition to levulinic acid and levulinic aldehyde, which according to Harries correspond to the decomposition of normal rubber, also succinic acid and acetonyl acetone.

The two last mentioned substances point to the formation of a small amount (20 per cent) of the 1.6-compound, by abnormal condensation in addition to the normal 1.5-dimethylcyklooctadiene during the polymerization of isoprene, and which yields both the above-mentioned substitution products by the decomposition with ozone. These substances, however, have up to now never been discovered in natural caoutchouc. Until it is possible to so adjust the conditions of polymerization that the synthetic caoutchoucs also represent uniform compounds, it cannot be expected that the synthetic caoutchoucs will equal the natural in technical adaptability. Steimmig's experiments embrace all the polymerising processes known at the time.

The problem of the synthetic preparation of caoutchouc has, therefore, just begun to be scientifically solved as regards the elementary points. The continuation of the study will surely yield many results worthy of note. A dangerous economic upheaval through the complete or partial crowding out of natural caoutchouc by the synthetic need not be expected to occur in the near future.

[8] *Ann.*, 1911, vol. 383, p. 188.

[9] Compare Harries: *Z. angew. Chem.*, 1912, vol. 25, p. 1,456.

[10] *Z. angew. Chem.*, 1914, vol. 27, p. 153.

[11] Compare F. Hofmann: *Z. angew. Chem.*, 1912, vol. 25, p. 1,462.

[12] *Ber.*, 1914, vol. 47, p. 350. See also Harries, *ibid.*, p. 573. Steimmig, *ibid.*, p. 852.

Cost in Cement Manufacture

The cost of power required in the manufacture of Portland cement reaches a higher percentage of the total cost of production than in most any other industry; and investigations seem to show that, when properly operated, there is little difference in the power required by different types of machines used in the processes. It is therefore evident that any reduction in the costs must be in the direction of the power used, and it is believed that the application of electric power can be made to materially reduce the expense of manufacture.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JUNE 19th, 1915

Published weekly by Munn & Company, Incorporated

Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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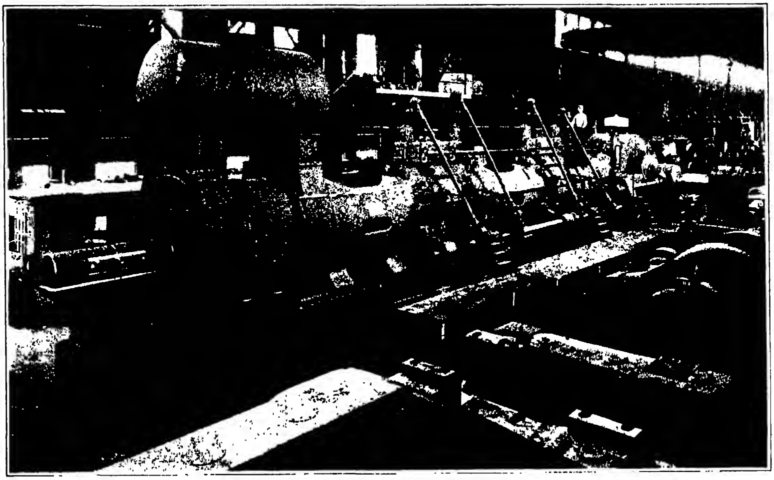
VOLUME LXXIX
NUMBER 2060

NEW YORK, JUNE 26, 1915

10 CENTS A COPY
$5.00 A YEAR



Valve gear side of a big gas engine. Blowing cylinder in foreground

Crankshaft end of big gas engine.

LARGEST AMERICAN INTERNAL COMBUSTION BLOWING ENGINE.—[See page 407.]

The Chemical Industries of Germany—II*

An Historical Review of Processes and Conditions

By Prof. Percy F. Frankland, F.R.S.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2059, Page 390, June 19, 1915

POTASH SALTS

Germany appears to be alone in possessing vast deposits of potash salts while the enormous value of these to agriculture was first demonstrated by Liebig and made public by him in his "Application of Chemistry to Agriculture and Physiology" in 1840. This work may without question be regarded as the foundation stone on which agricultural chemistry has been raised.

The celebrated deposits of potash salts were accidentally discovered in 1857 when boring for rocksalt at Stassfurth near Magdeburg in Prussia. Their industrial exploitation on an ever increasing scale was begun in 1861 by Grüneberg and Adolf Frank. In 1861 the production of crude potash salts was 2 000 tons, in 1912 it was 11 000 000 tons worth $44 000 000. Ninety per cent is used as manure (about one third in Germany itself) and 10 per cent in industries (about two thirds being worked up in Germany for carbonate caustic nitrate alum chromate and chlorate etc.). America is now experimenting with a view to obtaining potassium chloride from feldspar by the method used in the laboratory for determining alkalis in insoluble silicates and which consists in heating the silicate with a mixture of lime and calcium chloride. Whether it has any commercial future remains to be seen.

This is a matter of prime importance in the United States as potash salts are there used on an enormous scale especially for agriculture. Thus they consumed in 1900 Stassfurth potash salts worth $4 200 000, in 1910 $12,200 000 and in 1911 $15 200 000.[14]

EXPLOSIVES

I have already mentioned the importance of nitrates and of nitric acid and have referred to the employment of the great part in agriculture of the remainder the major part goes into the manufacture of explosives and into the coal tar color industry.

Black powder or gunpowder is said to have been discovered by the English monk Roger Bacon (1214-1294). Gun-cotton was discovered by Schönbein in Basle and Christian Böttger in Frankfurt in 1846.

Nitroglycerine was discovered by Sobrero in Pelouze's laboratory in Paris in 1847 and first manufactured on a large scale as an explosive by the Swede Alfred Nobel in 1862.

The disruptive properties of gun cotton are greatly moderated by gelatinizing by means of solvents (acetone acetic ester alcohol and ether etc.) and by mixing with nitroglycerine ballistite materials like cordite and other smokeless powders are obtained. There is another class of explosives which combine great safety in handling with enormous disruptive effect. Picric acid (discovered by Woulfe of London in 1771) but first used by the French under the name of Melinite for filling shells in 1881 and later by the English under the name of Lyddite. More recently this has been replaced by trinitrotoluene first proposed by Haeussermann in 1891 for filling shells and used by the British Service under the mark T N T. It is even less sensitive to shock than picric acid. Ammonal, used by the Austrians for shell-filling, is a mixture of T N T with ammonium nitrate charcoal and aluminum powder. It is both very safe and very powerful. T N T is much used for demolishing bridges. It is so insensitive to shock that it is not exploded on being struck by a rifle-bullet and when in a shell it withstands the impact of the latter piercing an armor plate.[15]

Tetra-nitro-aniline obtained by Flürscheim enjoys the unique position among explosives of having been discovered in this country. It is said to be equally safe and even more powerful than trinitrotoluene.

According to the late Oscar Guttman the production of nitroglycerine explosives in 1909 was as follows: United States 20 000, Germany 10 300, England 6 100, Transvaal 8 000, Canada 5 000, Spain and Portugal 3 500, Austria-Hungary 2 800, France 1 500 tons, Switzerland, Austria, Norway and Sweden, 600 tons each, Russia, Italy, Holland, Belgium 500 tons each, Greece 175 tons.

Explosives are of enormous importance also in civil life—in mining and engineering modern explosives have greatly accelerated progress and have rendered possible such works as the Panama Canal. They are also being now employed with great advantage in afforestation for loosening the ground in which trees are to be planted. The manufacture of explosives in Germany is very highly developed. The total German production of 40 000 000 kilogrammes includes dynamite explosives 10 000 000, ammonium nitrate explosives 16 000 000 and black powder etc. 14 000 000 kilogrammes. There were exported in 1908 explosives of a value of about $5 000 000 and in 1912 $15 000 000.

The world production of explosives is now about 400 000 000 kilogrammes or ten times the German total output. Great Britain has at Ardeer in Scotland the largest explosive factory (Nobel's) in the world covering 850 acres employing 1 800 men and 700 women and producing annually about 16 000 tons of all kinds of high explosives.

ARTIFICIAL SILK

An eminently peaceful industry which is closely related to that of explosives is the production of artificial silk and celluloid. The manufacture of artificial silk has grown up during the past twenty-five years for this product was first shown by Count Hilaire de Chardonnet at the Paris Exhibition of 1889; he discovered the method of its preparation while a student in the École Polytechnique at Paris and in 1891 formed a company at Besançon with a capital of $1 200 000 for its manufacture.

The chief kinds of artificial silk are: (1) Nitrated cellulose (soluble in alcohol-ether) silk (denitrated by ammonium sulphide) (Chardonnet silk). (2) Ammoniacupric oxide cellulose silk (Pauly, Fremery or Urban silk of the Vereinigte Glanzstoffabrik Elberfeld 1897). (3) Viscose-silk (CS_2 in presence of $NaOH$ or $Ca(OH)_2$ on cellulose) (Cross and Bevan). (4) Acetate-silk (acetic acid on cellulose) (Cross and Bevan).

Germany produces about 2 000 000 kilogrammes value about $6 000 000, exports 600 000 kilogrammes and imports 1 800 000 kilogrammes; the imported is principally alcohol silk due to disadvantageous alcohol tax in Germany. Germany is the principal user of artificial silk although the fundamental discoveries upon which the manufacture is based are largely due to French and English chemists. The world production is estimated at about 7 000 000 kilogrammes.

The distribution of the industry may be gathered from the following: France 7 factories, Germany 8, Belgium 3, England 2, Spain 1, Austria-Hungary 4, Russia 3, America 3, Japan 1.

Great profits have been made out of artificial silk (some of the companies paid 50 to 100 per cent dividends) and the price has greatly fallen since its introduction from $7 per kilogramme in 1903 to $4 in 1906 and $3 (poorer qualities $1 50 to $2) in 1910.

The celluloid industries furnish a particularly striking example of the manner in which chemical research and invention are able to enhance the value of the kindly gifts of the earth. Thus 1 cubic meter of wood has value as fuel about $1 50 (after boiling with lime, soda and sulphite) as paper pulp $8, ditto as paper, $14, and as pulp converted into artificial silk $400 to $1 200.

INDUSTRIES DEPENDENT ON SYNTHETIC ORGANIC CHEMISTRY

It is out of the profound study of synthetic organic chemistry which has been made during the past sixty years that the industries of artificial dyes, drugs, and perfumes have incidentally arisen. The earlier and pioneering achievements in synthetic organic chemistry are well distributed among the nations of Europe,[16] but during the major part of the sixty years the great bulk of the discoveries in this domain have been made in Germany. Organic chemistry is, perhaps, the branch of science which more perfectly suits the German mind and temperament. It involves the possession of those qualities in which Germans are so pre-eminent—the capacity for taking an infinitude of pains, the capacity to anticipate difficulties and organize means to circumvent them. It is, moreover, only possible to make substantial advances in the problems of organic synthesis if the master has at his disposition a number of highly qualified and docile assistants and apprentices, in a word, the master must be at the head of a large and efficient school of research. It is in the possession of such schools of research, both in the universities and in the chemical factories, that Germany has by two generations the lead of all other countries in the world.

While most of the professors of chemistry in British universities and colleges have under great difficulties and without any sort of encouragement been more or less successful in building up such schools of research, which are however by no means slavish imitations of the German model, the chemical manufacturers of England have with some notable exceptions, failed to establish anything worthy of the name of research laboratories in connection with their works.

It is in respect of the works research laboratory that there is the greatest contrast between the chemical industries of Germany and those of other countries and it is not surprising therefore that the present war should have served to emphasize the class of chemical products for which Great Britain is almost entirely dependent on Germany.[17] It is precisely those products—artificial dyestuffs, artificial drugs and artificial perfumes which are the outcome of the works research laboratories that are now in many cases unobtainable in consequence of the cutting off of the German sources.

The seriousness of the situation is apparent from the following figures relating to dyestuffs alone. The value of dyestuffs consumed in England annually is $10 000 000 and the value of trade in which these dyestuffs are employed is $1 000 000 000, while upwards of 1 500 000 workmen are dependent upon these industries. The total value of dyestuffs imported into the United Kingdom in 1913 was $9 460 275 of which Germany contributed $8 654 105.

Perhaps the most concise way of conveying a superficial idea of these industrial products of organic synthesis will be by means of the following classification.

I. *Artificial Products.*—Colors first obtained from aniline by Runge in 1834, by the action of bleaching powder. Aniline colors. Mauve was discovered by Perkin in 1856 and Magenta by Verguin in 1859. Azo-colors[18] were discovered by Griess in 1859 and introduced on an extended scale in 1878. The azo-colors have achieved an enormous importance and have practically banished cochineal and logwood from the dye-works. Some 2 000 azo-colors in use. Congo-colors, substantive cotton dyes, were discovered by C. Böttiger in 1884.

It must not be supposed that British color manufacturers have been idle from the days of Perkin; thus in 1880 a very original departure was made by Messrs. Read Holliday and Sons who introduced the principle of developing azo-dyestuffs on the fiber with their so-called ingrain or ice colors. Some of these have achieved a great success, thus 2 000 tons of p-nitraniline are now annually manufactured for the production of nitraniline-red and similar colors.[19] Again the discovery of primulin and the colors which can be derived from it by A. G. Green in 1887, is another very notable achievement.

Eosin colors were discovered by Caro in 1873.

II. *Artificially Produced Natural Products.*—This group contains substances occurring in nature and long valued by man. The chemical nature of these substances has been carefully ascertained by chemists who have then deliberately set to work to devise means for their artificial preparation at such a cost as to compete with and ultimately supplant the natural product. These campaigns against the commerce in the products of nature undoubtedly constitute one of the most remarkable phenomena in the history of the world. Bear in mind, it is the production and supply to man of the actual products of Nature, but more cheaply than they can be produced and supplied by Nature herself. These endeavors have already been successful on a very large scale.

Alizarin (the essential principle of the madder root) was first synthesized by Graebe and Liebermann in 1869. At the time of this discovery, the world production of madder was 50,000,000 kilogrammes roots (1½ per cent alizarin), representing 500,000 to 750,000 kilogrammes alizarin, value $11,250,000. In 1870 France had 20,000 hectares (50,000 acres) under madder cultivation, which soon disappeared after the introduction of the artificial product.

*A paper read before the Birmingham section of the Society of Chemical Industry on March 4th 1915.

[14] Macnab "Explosives" Inst. of Chem. Lecture 1914.

[15] Molinari.

[16] England and France were however more especially to the fore.

[17] Only about one tenth of the annual value of dyestuffs consumed in England is produced in England.

[18] Both azo and eosin colors were kept as secret products, until the colors were investigated by Hofmann and their mode of production published, to the great consternation of the inventors.

[19] G. T. Morgan, "Modern Dyes and Dyeing," Roy. Dublin Society 1914. Cain and J. F. Thorpe, "The Synthetic Dyestuffs and Intermediate Products," 1913.

The production of artificial alizarin was: 1873, 100,000; 1877, 750,000; 1884, 1,350,000; 1900, 2,000,000 kilogrammes (four fifths of this was produced in Germany).

A great number of most valuable artificial dyestuffs, more or less closely related to alizarin, but not occurring in nature, have been prepared by chemists, and the total value of the alizarin-color exports of Germany at the present time is about $5,000,000.

Indigo.—This most highly prized blue dyestuff of both the ancient and the modern world was first artificially synthesized by Adolf Baeyer in 1880, but it required seventeen further years of unremitting and laborious investigation in the works of the Badische Anilin und Sodafabrik at Ludwigshafen, and the investment of nearly $5,000,000 before laboratory synthesis was translated into a commercially successful industry, for it was in 1897 that the artificial indigo was put on the market.[19]

In 1896 the world production of plantation indigo (100 per cent) was 6,000,000 kilogrammes, value $20,000,000; four fifths of this was British, obtained from 1,500,000 acres in British India. In 1904 only 500,000 acres was under cultivation, and in 1913, only 300,000 acres (see Table IV.).

TABLE IV—INDIGO

	British East Indies		Germany	
	Cwt.	Exports, Value	Imports	Exports
1896	168,387	$17,848,350	$5,180,000	$1,597,750
1899	135,187	9,901,595	2,077,250	1,961,250
1902	89,750	6,174,185	921,750	4,615,500
1905	49,525	2,782,025	300,500	6,430,250
1908	32,490	2,124,245	220,500	9,663,750
1911	16,939	1,125,000	111,500	10,457,500
1912-14	$300,000 to $350,000			

The price of indigo (100 per cent) in 1897 was $4 per kilogramme and in 1913 $1.75 per kilogramme.

By varying the ingredients in the indigo-synthesis, many very valuable dyes related to indigo have been obtained. Thus the chlorine and bromine substituted indigos are manufactured as ciba-blue, brilliant-indigo and bromo-indigo. Again with sulphur instead of oxygen, thio-indigo-red, and thio-indigo-scarlet are obtained. Moreover, by using the anthracene-grouping in the indigo-syntheses a number of most important colors have been obtained, e. g., indanthrenes, of extraordinary fastness to light; alizarin-indigo; algol-colors (Rob. E. Schmidt), in all varieties of color, and of the greatest fastness to light. The discovery of these valuable dyestuffs provoked zealous emulation on the part of the azo-color chemists, who responded by placing some very excellent new products on the market under the name of benzolight colors.

Antique or Tyrian purple was perhaps the most highly prized of all colors in the ancient world. We know from Pliny that this dye was obtained from a rather rare snail living in the Mediterranean, and which he describes under the name of "purpurea." Paul Friedländer, of Darmstadt, succeeded in 1909 in extracting this color from certain glands of two different species of snail—*murex brandaris* and *murex trunculus*—which appeared to correspond to Pliny's description of "purpurea." He removed these glands from 12,000 individual snails, developed the color by a short exposure to sunlight, extracted it with suitable solvents and recrystallized it from quinoline. In this manner he obtained only 1½ gramme of the coloring matter, so that its extreme costliness, which Friedländer estimates at about $10,000 a kilogramme, is not surprising.

On investigating the chemical nature of this color he found that it was identical with the already known synthetical compound 6.6′-dibromindigo.

Drugs and Perfumes.—Not less remarkable are the achievements of organic synthesis in connection with pharmaceutical and perfumery products.

The production of artificial drugs and perfumes is in general only a branch of the artificial color industry, for in many cases the raw materials are the same, while the methods of investigation and synthesis are, of course, identical. But whereas the artificial color industry started in England, that of artificial drugs is entirely of German origin, and may be said to begin with the discovery by Liebig of chloroform in 1831, and of chloral hydrate in 1832. It was in 1869 that the chemical works of Schering, on the suggestion of A. Liebreich, produced chloral hydrate as a commercial article.

In 1887 began the discovery of artificial antipyretic drugs, the rivals of the natural quinine. The first of these was antifebrin, the properties of which were discovered accidentally in consequence of a mistake. A specimen of acetanilide in a Strassburg pharmacy was erroneously supposed to be naphthalene and was served out as such for some pharmacological experiments by Kahn and Hepp. On being taken, internally, its antifebrile effect was observed. Fortunately there was enough left for analysis, and it was found that the supposed naphthalene was the long known acetanilide, which soon acquired a great vogue for this purpose. About the same time antipyrin was discovered by Knoor, who erroneously thought that it was chemically related to quinine, and that it would, therefore, not improbably possess antifebrile properties. Direct experiment showed that it did actually possess these properties in a high degree, but subsequent research showed that it was in no way chemically related to quinine. These and numerous other artificial antipyretics have been a great source of income to their inventors in consequence of the continued prevalence of influenza during the past quarter of a century.

During the period that antipyrin was protected by patent it was sold at $30 per kilogramme, while on the expiration of the patent the price was reduced to $5 per kilogramme, which still allows a good margin of profit.

These discoveries have led to the systematic study by direct experiment on animals and human beings of innumerable chemical compounds with a view of ascertaining their physiological properties. The enormous amount of most laborious work which has been carried out in connection with synthetic drugs may be gathered from the fact that up to 1912 about 5,000 artificial products had been found to possess therapeutical value of one kind or another, but, of course, comparatively few of these have permanently established themselves in medical practice. Time does not permit me to do more than refer briefly to some of the simpler and better known synthetic drugs.

Thus of antipyretics, which have or have had some considerable vogue, are: Antipyrin; tolypyrin (dimethyltolylpyrazolone); salipyrin (antipyrin-salicylate); antipyrin mandelate (tussol, for whooping cough); neopyrin; pyramidon (three times as strong as antipyrin) dimethylamino-antipyrin); antifebrin; phenacetin (cheapest antipyrin excepting antifebrin, about $1.50 per kilogramme, and less poisonous than antifebrin); lactophenin, lactyl-p-phenetidine; aminophenacetin or phenocoll (also has an antiseptic action).

The above series derived from aniline affords a good illustration of the dependence of physiological properties on chemical constitution. Aniline itself is a powerful antipyretic, but is extremely poisonous, owing to its ready absorption and action on haemoglobin. By introducing the acetyl group the toxic properties are much reduced owing to its greater stability, although acetanilide is slowly hydrolyzed with liberation of analine, so that after a time the symptoms of aniline poisoning may supervene. The observation that acetanilide is partially oxidized in the system to *p*-aminophenol led to derivatives of the latter being tried. Thus phenacetin has been found to possess powerful antipyretics and greatly reduced toxic effects.[20]

Hypnotics.—Sulphonal was accidentally discovered to possess hypnotic properties in connection with experiments on the transformations of sulphur compounds in the animal system. A dog, which had been dosed with the newly discovered sulphonal, in Baumann's laboratory at Freiburg, i.B., was found to fall into a deep sleep.

More powerful hypnotics were found to result from introducing further ethyl groups:

$(CH_3)_2C(SO_2.C_2H_5)_2$. Sulphonal $\qquad$ $(CH_3)(C_2H_5)C(SO_2.(C_2H_5)_2$ Trional

$(C_2H_5)_2C(SO_2.C_2H_5)_2$ Tetronal.

In connection with the manufacture of sulphonal, I may refer to an interesting difficulty which was experienced by the Elberfeld Color Works owing to the appalling smell of the mercaptan from which it is prepared, and of which Emil Fischer and Penzoldt have shown that the human nose is still capable of appreciating 1/400,000,000 milligramme. In spite of this, German thoroughness has been successful in so perfecting the apparatus in which the manufacture is carried on that no nuisance is occasioned.

Veronal (diethylbarbituric acid) (E. Fischer and Mering, patented by Merck in 1903) is one of the most widely used hypnotics. Although it was formerly supposed to be practically free from toxic properties, in recent years cases of veronal poisoning have been known to occur.

Antineuralgics.—Salicylic acid, one of the first drugs to be artificially prepared (Kolbe, 1860), acetyl-salicylic acid (aspirin), and salol (phenylsalicylate), though extremely simple synthetic products, are almost exclusively made in Germany, with the result that their price has now greatly increased. Even synthetic phenol which is necessary for the above preparations, was exclusively made in Germany and kept down the price of coal-tar phenol. The price of phenol has now enormously increased from 7 cents per pound to 33 cents per pound, and is likely to go higher. (*Pharm. Journal*, 1915).

Anti-gout drugs (Uric acid solvents).—Piperazine (discovered by Hofmann in 1890), lysidine, urotropine (hexamethylene tetramine), atophane (α-phenylcinchonic acid).

Suprarenone.—This is of special interest. The active principle of the suprarenal glands known as adrenaline[21] had for some years been found to be of great value for increasing the blood-pressure, contracting the blood-vessels, and arresting haemorrhage. It requires the suprarenal glands of 40,000 oxen to prepare 1 kilogramme of adrenaline, but this substance has been artificially synthesized by F. Stolz, and is put on the market as suprarenine by the Höchst Color Works. The syntheses of adrenaline may be presented thus:

Catechol → Chloraceto-catechol → Methyl-amino-aceto-catechol → Adrenaline

$CH_2ClCOCl$ $\qquad$ CH_3NH_2 $\qquad$ Al-amalgam

Natural adrenaline is laevo-rotatory; the synthetic can be resolved by tartrate; the laevo is fifteen times as potent as the dextro.

The German color manufacturers are organized into two principal groups or trusts (Interessengemeinschaften). (1) Badische Company, of Ludwigshafen; Bayer Company, of Elberfeld; Berlin Aniline Company. (2) Cassella Company, of Frankfurt; Meister, Lucius, und Brüning, of Höchst.[22]

The share-capital of the above two groups in 1911 was $40,000,000 paying a dividend of 25.8 per cent, and probably now about $60,000,000, dividend 28 per cent.

In 1860-70 Germany imported about $12,500,000 worth of dyes per year, while in 1912, Germany exported about $50,000,000 and produced about $62,500,000 of dyes.

The composition of the personnel who carry on these German color works is at the bottom of their success. Take the works of Messrs. Meister, Lucius, und Brüning as an example. In 1913 the composition was as follows: Workmen, 7,680; managers, 374; expert chemists, 307; technologists, 74; commercial staff, 611. Contrast with the above the fact that the six English factories now producing dyestuffs employ altogether only thirty-five chemists, while evidence of their relative activities is again furnished by the circumstance that between 1886 and 1900 the English firms took out only eighty-six patents, whereas the six principal German firms were responsible for 948 during the same period.

Having shown that these German coal-tar color manufacturers are without rivals from the commercial point of view, I feel it to be my duty to point out also that their industry is carried on under conditions of labor which are highly creditable to the management.

Purchasing Coal on Heat Unit Basis

It is inevitable that large users of coal will insist more and more upon contracting for their fuel supplies on some basis other than that of a set price per ton. In spite of certain objectionable features and some opposition, which is not without cause for its existence, there is evidence of a steady increase in the use of what is generally termed the "heat-unit basis" for the purchase of coal. A simple illustration may serve as an explanation of this tendency: Three Illinois State institutions with substantially the same shipping rate received bids on coal supplies from dealers A, B and C, their respective prices being $1.45, $1.72 and $1.48 per ton. Now, as subsequently proved to be the case, A was able to deliver, and did deliver, coal with an ash and moisture content of 21 per cent and a heat-unit value which entitled him to a settlement price under the contract of $1.55 per ton. The deliveries by B, contained an ash and moisture total of 30 per cent and a heat-unit value which resulted in a settlement price of $1.12 per ton. Similarly, C with a total ash and moisture content of 33 per cent was entitled to a settlement price of $0.97.

It is seen that dealers A and C estimated their coals at substantially the same price, say $1.45 per ton. The intrinsic values, however, which are at least relatively indicated by the settlement price, are shown to have a difference of substantially 60 cents per ton. Similarly, dealer B, who estimated his coal as worth $1.72 per ton finds its actual value, or at least its settlement value according to the terms of the contract, to be $1.12 or 60 cents less per ton. The figures show also that a dealer may name his price per ton with very little knowledge as to the intrinsic value of the material. There is little if any relation between the price asked and the actual heat value to be delivered. Illustrations of such discrepancies could be multiplied indefinitely.—Bulletin 29, Illinois State Geological Survey.

[19] Baeyer's first patent for the synthesis of indigo from o-nitrocinnamic acid was taken out in 1880, and by 1897 there had been no less than [illegible] patents obtained in Germany for processes connected with the preparation of indigo.

[20] Chemistry of Synthetic Drugs, P. May, 1911.

[21] Discovered by Takamine in 1901.

[22] "German Coal Tar Companies," *Textile Mercury*, January 9th, 1915.

Forging Shrapnel Shells*

Some Details of Modern Methods Now in Use

By Douglas T. Hamilton

WITHIN the last few months, many methods have been suggested for making shrapnel forgings, but a comparatively small number have been put into use. Practically speaking, no two governments have adopted the same method. The Russian government uses double-acting horizontal hydraulic forging presses in which two operations are performed at the same time on different forgings. For instance, while the punch in one end of the machine is piercing a heated billet, the ram on the return stroke performs the hot drawing operation on another shell located at the opposite end of the machine. In this way a shell is completed at each cycle of the machine—forward and return stroke. The French government, up to a short time ago, used steam hammers for this purpose, and produced shrapnel forgings in practically the same manner as a drop-forging is made, the punch being carried in the ram of the press and the die held on the bed. This is rather a slow process and requires more than one heating to complete the forging. The German government uses a horizontal hydraulic forging press for piercing the billet and a steam-driven machine for drawing the forging, which receives its motion from a rack and pinion. This method has the advantage over the hydraulic press of being more economical in the consumption of power.

The practice followed by different concerns in this country and Canada, at the present time, differs to a large extent. Some manufacturers are using a method that dates back as far as 1890. Others are using a more improved method developed about 1895, whereas about three concerns are using a still more improved method developed in the last three months.

The first method (known as the Caley process) of making shrapnel forgings in this country had its inception about 1890 and was used almost exclusively until 1895. This comprised a slug-forming and billet-piercing operation followed by a successive reduction and elongation of the forging through drawing dies. The order of these operations is shown diagrammatically in Fig. 1. The information given herewith pertains to the making of a forging for a 3-inch shrapnel shell. As shown at D, a billet of steel 3¼ inches in diameter and 6½ inches long was cut off from a bar with a cold saw, and formed into a cone shape under a vertical hydraulic press having a capacity of 100 tons. The billet was heated in a furnace to about 1,900 deg. Fahr., dropped into the impression in the die and forced into shape by a hydraulic plunger having a depression in the lower end which centered the blank. The result of this operation is shown at F.

The next step was to anneal the billet, after which it was pierced as shown at C, and at the same time slightly elongated. This operation was handled in a hydraulic press. On a 0.70 per cent carbon steel billet the pressure on the punch in the piercing operation was 20,000 pounds per square inch and the machine used was a vertical hydraulic forging press of the type referred to having a capacity of 100 tons. From the piercing operation the forging was taken direct without annealing to the horizontal hydraulic draw press, and as is shown at H was located on a punch and forced through a series of drawing dies which gradually reduced the shell to the correct diameter, 3⅛ inches, and drew it out to the required length, about 8⅝ inches.

A point worthy of attention is the preparation of the cone-shaped billet. The smallest end was made slightly smaller than the smallest reduction die in the series. The reason for this was that if any drawing were done on the end of the shell the front corner would be drawn over and deformed, increasing the amount of machining required. The drawing dies in this case were six in number, as shown at H, and were reduced on a sliding scale of the following proportional reductions. First, 0.100 inch; second, 0.050 inch; third, 0.060 inch; fourth, 0.040 inch; fifth, 0.030 inch; and sixth, 0.020 inch. This gave dies of the following sizes, in inches, starting with the largest in the series: 3.355, 3.275, 3.215, 3.175, 3.145, and 3.125.

The drawing punch was lubricated occasionally with graphite. After drawing, the forging is annealed to obtain the proper physical qualities. This method of making forgings for a 3-inch shrapnel shell is capable of producing 400 in ten hours.

About 1895 the following method, known as the Hollinger process of making shrapnel forgings, was devised. Instead of making the billet conical in shape before piercing, this preliminary operation was dispensed with, and to facilitate the work, as well as to reduce the friction of the flowing metal, the arrangement of the piercing punch and die was changed. This process is shown in Fig. 2, and was accomplished in a hydraulic press provided with two cylinders, one located at the bottom and the other at the top of the press.

The operation was as follows: The die a was held in a movable frame b and the piston c acted first. The first position after the billet was dropped into the die is shown at B. Here the die a and punch d remained stationary while the piston c descended, pushing the billet through the die and over the punch. When the piston reached the end of its stroke, as shown at C, the lower cylinder began to act and the frame carrying the die was raised. This frame, as shown at D, carried a stripper plate e which removed the pierced billet from the punch and located it so that it could be picked off with a pair of tongs. A subsequent operation of hot-drawing as shown at E was required, which is similar to that described in the first method. The method just described was used chiefly for 6- and 8-inch shrapnel and projectile forgings, and at the present time is still used for 3- and 6-inch shell forgings. It requires much less power and turns out a better and more concentric forging than the method previously described. The production on 8-inch shells is about 180 in ten hours, and 250 on the 3-inch shell.

The increased demand for shrapnel within the last few months has been instrumental in bringing about a radical improvement in the production of forged shells. Previously, the aim was to get the internal diameter as close as possible to the finished size and to do comparatively little machining on it; in fact, this is still, in a great number of cases, one of the requirements. While at first glance this would appear to be the logical way of handling the work, on further investigation it is found that the forging of the shell to the comparatively correct size is much more expensive than to leave sufficient metal to machine all over. In the first place, a hydraulic machine of 100 tons capacity costs considerably more in initial outlay than a turret lathe, and in

* Reproduced by courtesy of *Machinery*.

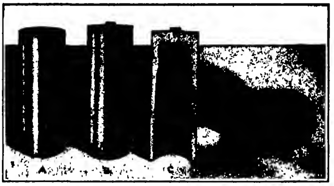


Fig. 4.—Examples of shrapnel forgings turned out on a power forging machine.

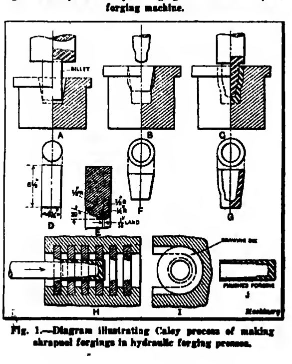


Fig. 1.—Diagram illustrating Caley process of making shrapnel forgings in hydraulic forging presses.

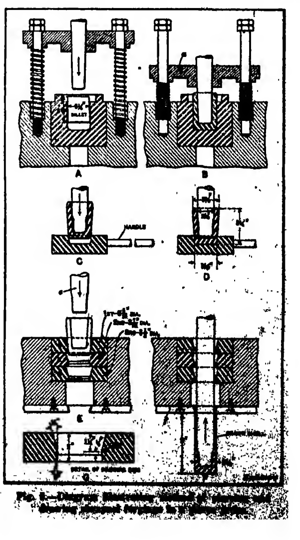


Fig. 2.—Diagram [illegible]

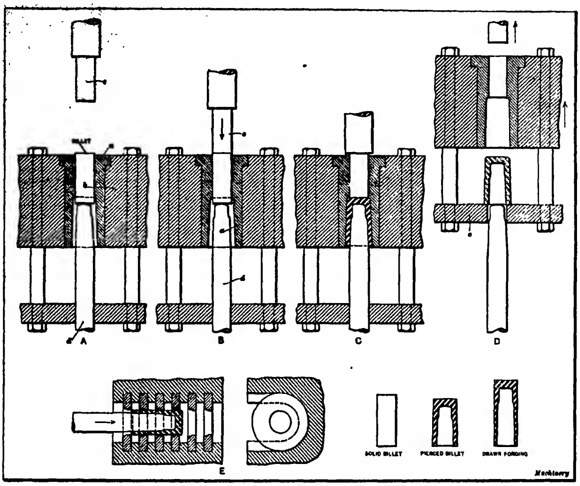


Fig. 2.—Hollinger process of making shrapnel forgings.

the second place it is more expensive to operate. The cheapest method of making a shrapnel forging is to rough-forge it to approximately the correct shape and then finish to exact shape and diameter in turret lathes or semi-automatic chucking machines. This simplifies the forging process and also decreases the production costs.

One of the later methods of making shrapnel forgings is shown diagrammatically in Fig. 3. A billet of steel 6⅛ inches long by 3 3/16 inches diameter is heated to a temperature of from 1,900 to 2,100 deg. Fahr., and then dropped into the impression in the die *a* held in a special cast-steel die-holder *b*. To do this, die *a* is drawn out from beneath the punch, punch guide *c* removed and the billet dropped in. Then the guide is replaced and the die-holder slid in until it contacts with the stop *d*. The press is now operated, and as shown at *B*, advances, piercing the billet and making the metal flow up around the walls of the punch.

The punch now retreats, carrying the centralising guide *c* with it. The die-holder is now drawn out from under the punch onto a bracket projecting from the bed of the press. The high-carbon steel, hardened block *e* then drops out of the die, as is also the case with the finished forging. This block *e*, of course, is heated up to a considerable extent due to the hot metal resting on it so that several blocks of this kind are provided. In the illustration, as shown at *C*, centralising guide *c* is shown attached to the punch. In actual operation this is not the case. When the punch rises, guide *c* is stripped from it by the stripper plate *f* so that the guide is gripped with a pair of tongs and laid down on the bed of the press until a fresh heated billet has been placed in the die impression ready for the next piercing. The punch is made from special hot punching steel and the die from chilled cast iron. The production of forgings by this method for a 3-inch shrapnel shell is about 600 in ten hours.

The amount of metal left for machining by this method varies from 1/8 to 3/16 inch on the internal and external diameters. The forging after annealing is then machined inside and out on turret lathes, or semi-automatic chucking machines. The accepted method is to first machine the internal diameter and then hold the shell on an expanding arbor and machine it on the external diameter.

One of the latest developments in the art of producing forgings for shrapnel shells is the adaptation of the power forging machine to this work. As has been previously mentioned, there are several methods of producing shrapnel shells, and as it has been conclusively proved that the forged shell is superior to the shell made from bar stock, it is only natural that several methods for making the forgings would be developed. In the forging machine method, a bar slightly larger than the finished diameter of the forging is cut off, making a billet about 5⅛ inches long. This billet, for a 3-inch shell, weighs about 9¼ to 9½ pounds.

The billet is heated to a white heat in a furnace, the temperature being about 2,000 deg. Fahr., depending on the carbon content and other constituents in the steel, and is then placed in the lower impression of the forging die. The machine used for this size of forging is a standard upsetting and forging machine provided with a special crankshaft. Upon being operated, the lower plunger, which is larger than the diameter of the powder pocket in the shell, advances and pierces the billet. The pierced billet is then raised to the next impression, and the machine again operated. The second punch is longer than the first and smaller in diameter. The billet is forced up on this punch, which reduces it in diameter and increases its length. After the second impression the partially formed shell is then placed in the third or final die impression, where it is given two blows, being given one half turn after the first blow to form it more perfectly. The operations just enumerated are performed with only one heating of the billet, and the production of a 3-inch shell ranges from 400 to 450 perfectly formed rough forgings in ten hours.

The dies for this work are, of course, constructed upon a somewhat different principle from the ordinary forging die, because in this case it is necessary to make the metal flow upon the punches. The dies, therefore, are so constructed that they recede as the punch advances, which tends to make the metal flow up on the punch. The practicability of this method is well illustrated by the samples shown in Fig. 4. Here *D* is the rough forging just as it comes from the machine, with the exception that the mouth has been trimmed. *C* is a section of a shell made from low-carbon steel about 0.30 per cent carbon; *B* is a shell made from 0.50 per cent carbon, 3½ per cent nickel steel. This has been rough-turned, as the illustration shows. The homogeneity of the forgings is clearly indicated. *A* is a forging made from low-carbon steel, finish-turned.

One of the most interesting points about this method is its cost as compared with shells made from bar stock. To produce a 3-inch shell from bar stock requires about 22 pounds of material, and on metal costing 10 cents per pound, a bar shell—exclusive of machining—costs $2.20; to produce the same shell on a power forging machine requires about 9¼ to 9½ pounds, and figuring on 10 cents per pound the cost for material is only $1—a saving of $1.20 on each shell. Furthermore, the production of shells from bar stock on automatic machines is about twelve to fifteen per day. The number of forgings that can be turned out in the same time is 400 to 450, and the number that can be machined in this time varies from forty to fifty for two operations. It is therefore evident that the production of shells by forging is far superior to the bar method, and the forged shell is more satisfactory from every standpoint.

Another interesting development in the forging line is shown diagrammatically in Fig. 5. This method comprises three operations, and is handled in a No. 80½ Bliss press capable of exerting a pressure of 1,200 tons. A billet 3¼ inches in diameter by 3⅝ inches long is

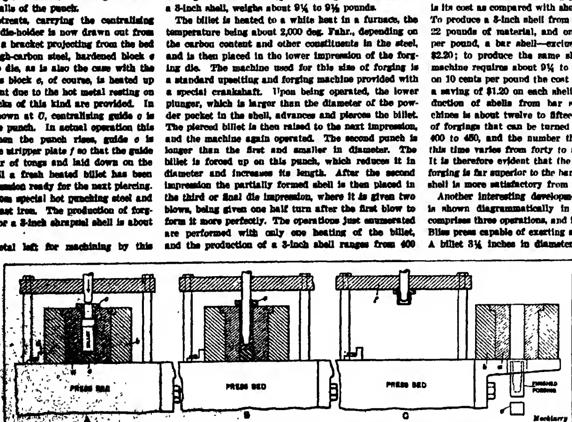


Fig. 5.—Improved method of making shrapnel forgings in one heat and operation.

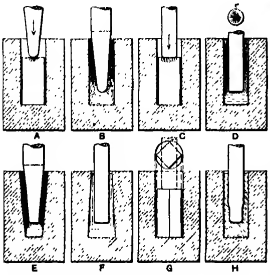


Fig. 6.—Diagram illustrating flow of hot metal while being pierced.

heated in a furnace to 1,876 deg. Fahr. and then quickly placed in the die shown at *A*. The press is operated, and the punch in descending pierces the billet, being guided by the guide *a*, as shown at *B*, which also acts as a stripper. The forging retains its heat to a certain extent after this operation, the temperature being about 1,380 to 1,425 deg. Fahr. This is sufficient to perform the second minor operation which, as shown at *C* and *D*, consists in forcing the heated billet into the die-block to reduce the diameter of the lower end end facilitate the succeeding operation. This reducing operation is performed with the same type of punch as is used in the succeeding operation, and the die-block is simply laid on the top of a bolster while the reducing is being done.

The final forming or drawing of the forging is accomplished as shown at *H* and *F*, the same type of press, being used for this purpose.

In the manufacture of shrapnel shell forgings, the first operation is that of piercing, and to accomplish this satisfactorily, it is necessary to understand the action of a piercing punch on a semi-plastic billet of steel. There are certain fundamental laws governing the flow of metals under pressure and a study of these is of exceptional interest. An attempt has been made in Fig. 6 to illustrate diagrammatically some of the principles involved, and in the following discussion it should be understood that the billet is made from 50-point carbon, 70-point manganese steel, 6¼ by 8$\frac{1}{16}$ inches in diameter.

At *A* a round-end tapered punch is shown in contact with the heated billet, and the lines show the possible flow of the metal, i. e., the material commences to "pack" at the end of the punch. In this case the walls of the die are straight. At *B* the billet is being pierced, and the resultant effect on the flow of the metal is indicated. Here it will be seen that the pressure increases as the punch descends, because of the wedging action on the metal and the friction between the surfaces of the sides of the punch and die. The pressure on the end of a punch of this shape is about 20,000 pounds per square inch.

By leaving the sides of the die of the same shape as at *B*, but making the end of the punch square instead of round and not tapered, different action is caused. When the flat punch, as shown at *C*, first contacts with the metal, the pressure required is greater than at *A*, but as soon as the metal commences to flow as at *D*, the pressure decreases. For instance, suppose the pressure required at *B* to pierce the billet was 100 tons; on the same material at *D* the required pressure would be only 70 tons—a decrease of 30 per cent. The metal, however, does not follow the sides of the punch as closely at *D* as at *B*, and this accounts in part for the reduction of power required. The action of hot flowing metal on the face of a square punch is just the reverse of what would naturally be expected. Instead of the punch wearing away at the edge, the center first shows signs of wear as indicated at *e*. Seams are opened up in a radial direction caused by the hot metal attacking the softest parts in the face of the punch.

Again, a different condition exists to that shown at *B* and *D*, when both the die and the punch are tapered as shown at *E*. Here the friction of the extruded metal on the walls of the die and sides of the punch is excessive, and it is practically impossible to produce a satisfactorily pierced billet in this manner. From a theoretical standpoint, the conditions shown at *F* are ideal. Here the sides of the punch are straight, the end flat, and the walls of the die taper or increase in diameter toward the bottom. In this case the friction of the flowing metal is greatly reduced because of the lessening of the wedging action. Other considerations, however, make this method impracticable.

A still greater reduction in the pressure necessary to pierce a billet is shown at *G*. Here a square billet instead of a round one is being pierced. In the plan view it will be noticed that the friction on the walls of the die is greatly reduced, and the pressure continues low until the extruded billet contacts all around with the surface of the die. The completed product, however, is inferior to that made from a round billet. From the previous remarks it will be seen that a punch and die that would best meet the requirements is one having a rounded end as at *B*, straight sides as at *D*, and straight walls in the die. The most satisfactory punch and die for piercing shrapnel forgings when all the variable conditions are considered would be as shown at *H*.

Plating by Impact

An account has been published of a metal spray process of plating, the invention of a Swedish engineer, and from a patent recently issued it appears that a similar process has been in course of development by Mr. C. Francis Jenkins of Washington, D. C., better known as the inventor of the now standard type of motion-picture projecting machine.

This process can perhaps be best understood if one remembers that when an electric lamp bulb gives way a discoloration of the inside of the bulb occurs; and also that when a fuse plug "blows" the mica cover is discolored. This color is black when the fuse is of lead, but it is a reddish color when a piece of copper wire is used. This would seem to indicate some kind of a de-

Early experimental apparatus using electric fan motor to operate the feed rolls.

posit resulting from the blowing of the fuse, that it is not completely volatilized. Under a magnification of 300 diameters, or more, minute particles of a copper wire are discovered, adhering to the cover of the fuse plug, and when a common visiting card is used for a cover instead of the mica, a decided deposit is attained. Repeated charges of such a fuse result in a complete coating on the card. When this surface is burnished with some smooth, hard object, a shiny, polished metal surface results.

A fuse used in this manner is in effect a gun which throws out a shower of miniature shot so small as to be invisible to the naked eye, and this would operate successfully for covering almost any surface but for the annoyance of the frequent replacements with short pieces of copper wire.

This led naturally to the development of a special "gun" into the barrel of which a copper wire is continuously fed. A pair of small rollers actuated by a motor pulls the wire off the supply spool and projects it across the barrel until the end touches the opposite surface. The inner lining of the barrel and the propelling rollers are in series in an electric circuit, though insulated from each other, so that a short circuit is formed between the rollers and the lining, and the wire is instantly melted, and the heat of the wire causes it to be thrown out of the barrel against any object held in position for that purpose. When a plurality of wires are used, or a flat ribbon, in order to cover a larger area in a given time, it is found desirable to add a propelling force, and this is done by introducing into the barrel behind the wire a small charge of explosive gas, i. e., oxy-hydrogen gas, gasoline vapor, ether, or common city gas properly mixed with air will answer. The melting of the wire explodes the charge which projects the miniature metallic particles, that are momentarily suspended in the gas, against the object to be coated. As the wire is steadily fed across the barrel, and the melting is instantaneous, there are time intervals during which new charges of gas are introduced following successive ignitions, and a succession of miniature explosions following each other with rapid frequency, something like the exhaust of an automobile motor.

It has been found that objects of a great variety can be coated in this manner and that any electrically conductive material can be used for the purpose. Coatings of lead, tin, zinc, aluminium, iron, copper, silver, and gold are readily formed in this manner. The different melting points of the different metals is taken care of by means of an adjustable rheostat in the melting circuit. A coil is better than a grid, for reasons not necessary here to explain.

Wood, metals, fabrics, plaster, wax, glass, in fact almost any substance, can be successfully coated. Metallic platings of one's thumb can be taken in this manner, for it seems that the metallic particles, being so very, very small, give up what heat they carry so quickly that no unpleasant sensation results. With wax or glue casts one can produce a shell of extreme thinness by melting out the glue in hot water. In like manner ribbons of extreme thinness can be made as a continuous process.

One of the meritorious features of this method is its great economy, for all of the heat developed in the melting of wire is usefully employed; none of it is wasted. Articles which would be destroyed in an acid electroplating bath can be coated, and coating by this process is many times more rapid than electroplating.

The accompanying line drawing illustrates the general construction of the gun, *B* being the stock, *A* the barrel, lined with mica, as shown by the heavy black line *D*, with a conductive lining *E* electrically connected through one of the wires *I* to the source of current. Another of the wires *I* is electrically attached to the gun barrel and the wire-propelling rollers *H*. The third of the wires *I* goes to the latch *S*, which is an electric switch controlling the motor (not shown) which actuated the rollers *H* through a flexible shaft. *G* is the wire to be volatilized, and *J* is a tube which leads explosive gas into the barrel of the gun. A small ball in the enlargement of the tube *J* near the upper end serves as a check valve, preventing "backfire" down the tube.

The operation of the gun is perhaps almost obvious from the drawing, the wire *G* being fed forward by the rotation of the rollers *H*, soon comes into contact with the inner lining *E* of the gun barrel and thereupon is instantaneously melted. The melting of the wire explodes the gas which has meantime entered the gun

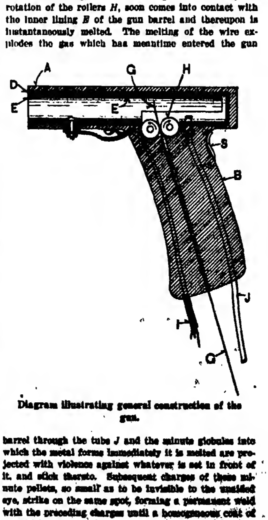


Diagram illustrating general construction of the gun.

barrel through the tube *J* and the minute globules into which the metal forms immediately it is melted are projected with violence against whatever is set in front of it, and stick thereto. Subsequent charges of these minute pellets, so small as to be invisible to the unaided eye, strike on the same spot, forming a permanent weld with the preceding charges until a homogeneous coat of any thickness desired results.

Tin, says a writer in the Bulletin of the Imperial Institute, has always been, to a large extent, a British product.

The Largest American Gas Engine

The largest single tandem gas blowing engine ever constructed in the United States was on exhibition recently at the works of the Mesta Machine Company, West Homestead, Pa. The gas cylinders are 46 inches in diameter, the air cylinder 84 inches in diameter with a common stroke of 60 inches. The engine will run at a speed of from 45 to 85 revolutions per minute, depending upon operating conditions. The accompanying illustrations show the gas engine on the erecting floor of the Mesta Machine Company and gives a good idea of how the engine will appear when finally erected at the plant of the Pennsylvania Steel Company, Steelton, Pa., where it is to be employed, because the platform in the foreground is approximately at floor level relative to the engine.

When gas-blowing engines were first introduced in the United States many objections were voiced on account of the great number of moving parts, but the view of this big machine, which show the valve operating side, proves that this objection is no longer valid.

The air end is equipped with Mesta automatic plate valves, which require no valve gearing. The use of these valves has made possible the placing of the air cylinder in tandem with the gas cylinders so that the air cylinder piston can be directly driven through an extension of the gas cylinder piston rod. This arrangement noted is much simpler than that of placing the air cylinder on the opposite end of the bed plate to the gas cylinders, which method has been so generally used in the design of gas-blowing engines in the United States.

The engine is of the center crank type. A double bearing bed plate is used with this crank and results in an equal distribution of the stresses.

At the present time a duplicate unit is being built, and more complete information, with test results, will be available as soon as the engine is put in operation.

Death of Pierre-Emile Martin

Pierre-Emile Martin, the inventor of the open hearth process of making steel, died on May 23, in his ninety-first year. He was born at Bruges, August 18, 1824.

It was only recently that the Iron and Steel Institute, England, had awarded to Martin the Bessemer Medal in recognition of his services in the manufacture of steel; and the statements made by Dr. Arthur Cooper, acting as president of the Institute in making the presentation, which was through a representative of the French Embassy, tell very clearly the history of the developments accomplished by Martin, as follows:

"Pierre-Emile Martin (Fourchambault, France), the recipient of the Bessemer Gold Medal of the Iron and Steel Institute, is one of the last of the pioneers connected with the great development in the manufacture of steel which took place in the latter half of the nineteenth century. He is the inventor of the process for the manufacture on a practical scale of open-hearth steel, for which his first patent was taken out in July, 1865. The process, which consists of melting pig-iron with scrap steel and iron oxide, has ever since been known on the Continent as the Martin process, but in this country it is commonly called the 'open-hearth process.' The actual discovery that steel could be made in this way was not new. Réaumur, in 1722, had already produced steel by melting a mixture of pig-iron together with scrap and iron oxide, but his experiments had never gone beyond the laboratory stage. Many metallurgists subsequently endeavored to follow the method indicated by Réaumur, but the difficulty of obtaining a sufficiently high temperature in the melting hearth proved an obstacle which none of them could overcome.

"The invention of the regenerating furnace by Sir William Siemens at length overcame this difficulty, and in the early sixties Pierre Martin began experiments at Sireuil, in France, with a Siemens furnace of 1 ton capacity. After many trials and disappointments he at length succeeded in producing open-hearth steel of regular quality and composition, and the process was taken up by two of the leading French steel works. The success of the new process naturally aroused the attention of Martin's competitors, and it was not long before the validity of his patent rights was attacked on the strength of Réaumur's prior publication of the results obtained 123 years earlier, although these had led to no practical result. Martin, not having the means to defend the lawsuits brought against him, was compelled after two or three years to give up the struggle against his opponents and to retire into private life. For many years his existence was forgotten, although the process had always continued to be associated with his name. When it became known a few years ago, through the Comité des Forges de France, that Mr. Martin was still alive, steps were immediately taken to recognize his claim to the merit of the invention which had been denied to him in earlier years, and at a banquet held in Paris in June, 1910, the steel-makers of Europe united to do him honor, and he was created by the French Government an Officer of the Legion of Honor.

"By the time Martin had perfected his method, the Bessemer steel-making process, which had been invented eight years earlier, already completely held the field, and the Martin process, especially on account of its higher cost, was unable for many years to make much headway against its powerful rival. The introduction in 1879 of the basic-lined furnace of Thomas and Gilchrist, by which phosphoric iron became available for conversion into steel, gave a great impetus to the manufacture of steel in the open-hearth, and the production of open-hearth steel (Martin steel) began from that time to increase steadily. In point of quantity it has now far out-distanced that produced by the Bessemer process, the world's production of steel for 1913 having been 74 million tons, of which 44 millions were made by the Martin process and 30 millions by the Bessemer process."

Light-Stroke*

There is an Italian proverb, "All diseases come in the dark and get cured in the sun." Interpreted from the standpoint of modern bacteriology and sanitary science, this statement has something to commend it, for light is to-day recognized as a potent defense against pathogenic micro-organisms by virtue of the destructive action which it exerts on them. Light, however, unquestionably has pathologic as well as physiologic effects on higher organisms. Under ordinary circumstances, we are exposed to sunlight of moderate or moderated intensity for limited periods. Exposure to intense sunlight, on the other hand, is by no means an innocuous procedure. Freckles are a familiar indication of a physiologic response to light, since they make their appearance on those parts of the body which are exposed to the sun's rays. Predisposed individuals react with more pronounced cutaneous symptoms under conditions in which sunlight is believed to play a rôle as a causative agent. Indeed, the skin is not the only organ which may react.

In this connection, the phenomenon of sunstroke is at once suggested. This term is, however, subject to much confusion and misconception. Some of the symptoms attributed to it are, without question, associated with heat exhaustion induced by elevated temperatures. There is some evidence in medical literature of the possibility of what Manson has termed sun traumatism, in which the heat regulation may not be alone at fault: for precisely similar effects have not been observed after exposure to heat from such artificial sources as furnaces. In so-called sun traumatism the morbid state is characterized as a rule by sudden death occurring without a warning. The sense of distress in a hot sun is not precisely like that provoked by a hot fire. This justifies one in raising the question as to whether the sunlight as such may not produce serious pathologic consequences, particularly if the subjects have not become gradually habituated to sun exposure.

The photodynamic action of certain organic substances, to which attention has been called of late, may have a bearing on the problems raised by some of the pathologic effects of light. It has been shown that injection of suitable sensitizing compounds into albino mice (which lack skin or hair pigments to protect them against the direct action of the light rays) renders the animals peculiarly irritable when kept in the light, though they show no untoward effects in the dark. Hematoporphyrin, a derivative of the pigment of the red blood corpuscles belonging to the group of investigated photodynamic substances, is of special interest because it is actually known to arise in the animal body under pathologic conditions. The symptoms which the animals treated with hematoporphyrin develop in the light are not due to any inherent toxicity of the compound itself. They ordinarily consist of lesions of the skin, accompanied by subcutaneous edemas and other severe effects. These may assume an acute or a chronic form and are not infrequently fatal in their experimental outcome.[1] In trials on himself, Meyer-Betz[2] has actually demonstrated the photosensitizing effect of hematoporphyrin on man. The most recent progress in this field is represented by Hausmann's ability to sensitize animals with porphyrins to such a degree that profound reactions are produced immediately on exposure to light.[3] In his earlier work, to which reference has already been made, the cutaneous symptoms usually were the first manifestations of abnormality, disturbances of the central nervous system making their appearance much later, if at all. By Hausmann's new technic it is possible to render animals so responsive to the effects of light that as soon as they are exposed to the rays they promptly enter into a narcosis terminating fatally in a few minutes. By treatment with the light of a quartz lamp, suitably prepared, mice manifest the chronic forms of this sensitization. The ultraviolet light is also concerned in the change. Brief treatment with light from a quartz lamp may lead to necrosis.

This intensely acute mode of death by exposure to light has been expressively designated as light-stroke (*Lichtschlag*) by Hausmann to distinguish it from the manifestations of true heat-stroke. It offers an experimental analogy, perhaps, to the obscure harmful effects of sunlight which still await a rational scientific interpretation.

* *Journal of the American Medical Association.*

[1] Hausmann, W.: Die sensibilisierende Wirkung des Hämatoporphyrins. Biochem. Ztschr., 1910, xxx, 276; Strahlentherapie, 1913, iii, 112.

[2] Meyer-Betz: Deutsch. Arch. f. klin. Med., 1913, cxii, 476.

[3] Hausmann, W.: Ueber die sensibilisierende Wirkung der Porphyrine, Biochem. Ztschr., 1914, lxvii, 309.

Correspondence

[*The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.*]

Flying-Boat Hulls

To the Editor of the Scientific American Supplement:

In the Scientific American Supplement of March 6th, 1915, is an article by Mr. Carl Hawes Butman, relating to experiments conducted at the Model Basin in the Washington Navy Yard under the direction of Naval Constructor H. C. Richardson, and a report, which has been published by the Langley Aerodynamical Laboratory of the Smithsonian Institution.

Mr. Butman says: "A model was designed to obviate the defects of the flat scow-bow type, by introducing the V type bottom for parting the water rather than forcing it aside. An earlier model of the V type caused a great amount of spray, and to overcome this the V section was made full, but as this only increased the spray, the V sections were made hollow, which brought about the desired results; holding the spray down, increasing the planing effect, and reducing the resistance."

I beg to make the criticism that anyone reading the above paragraph, and other portions of Mr. Butman's article, would get the impression that the department at Washington had made some new discoveries and created radically new designs. In other words, that this department had discovered the advantages of hydroplane hulls having a V section, and preferably concave V sections, and, as a result of such discoveries, had perfected models which obviated the defects of the flat scow-bow type.

It appears to me that Mr. Butman's article is rather partial to the department at Washington because, if he is familiar with the development of the hydroplane, he knows that the writer had designed and produced hydraulic boats a number of years prior to the date of the experimental work at Washington, and that such boats had concave V sections.

I have read Mr. Richardson's report published by the Smithsonian Institution, and also a similar paper read by him and published in a technical journal, and, in view of the fact that he attaches so much importance to the V type of hydroplane, think that it would have been only fair and a courtesy in keeping with the etiquette of his profession to have made some reference to my work in this direction.

Mr. Richardson in his paper gives Naval Constructor Hunsaker credit for suggesting a formula, a matter of insignificance in comparison with the discovery of new principles and designs which have revolutionized high speed boats, and probably will be of inestimable value in flying boats.

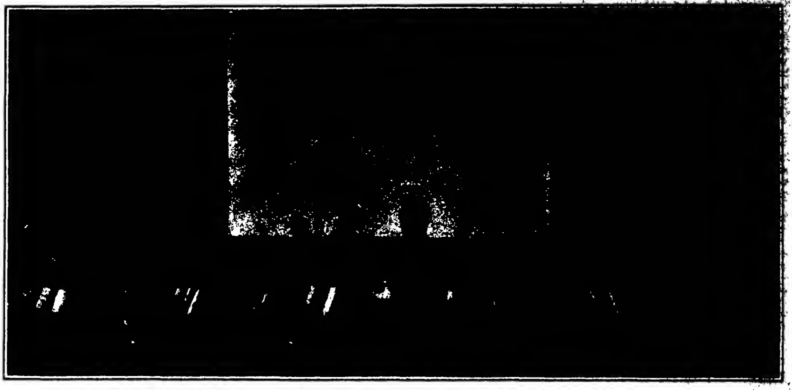
The writer spent several years in France developing the hydroplane, beginning in 1907, and was the first to discover, design and build hydroplane boats having the V section, and the first to adapt hydroplane principles to boat shaped hulls.

Aside from the discovery of principles, I produced practical designs which are closely copied to-day. I also published in English papers in 1909 and 1910 a number of articles giving much information covering the hydroplane subject, part of which has been verified at later dates by different experiments in the Model Basin at Washington.

William H. Fauber.

Brooklyn, N. Y.

A Correspondent writing in *Power* says: "A telephone receiver has been my constant friend for years, for various uses, one of which is in connection with calipering, especially the work inside of engine cylinders. The most convenient way is to have the two sides of the calipers insulated from each other. The work in the lathe completes the circuit, causing a click in the receiver. An ordinary pair of calipers may be used with a cigarette paper between the work and one side of the calipers.



Rendering "Prometheus" with colors. As the orchestra played light of changing hue illumined the screen.

The Art of Mobile Color

And a Discussion of the Relation of Color to Sound

By M. Luckiesh

THE dream of an art of mobile color is by no means of recent birth. Doubtless for centuries such a possibility has dwelt in the imagination of artists and investigators in color science. Yet the realization of such a dream is perhaps many years in the future owing chiefly to the fact that definite constructive investigation has not been directed toward the mysteries of the emotive and expressive value of colors. That mobile colors may be employed in such a manner as to make a somewhat similar appeal through visual perception as sound music does through the aural apparatus, certainly appears no more improbable than did the solution of many of the mysteries of yesterday. The development of such an art probably will not be left to a single branch of science but experimental psychology must furnish a large part of the constructive data upon which such an art will be founded.

It is the object of this brief article to suggest the general trend that the investigation must take, after discussing some of the superficial attempts that have been made to relate colors and sounds. Therefore the subject will be treated from two viewpoints; first as to relation of colors and sounds, and second from the viewpoint of an art of mobile color, independent of any other art. The treatment from the first viewpoint is not entirely one of choice. In fact one interested in the development of an art of mobile color, independent of any other art, feels compelled to discuss the possibility and justification of such a relation, because in the few instances that colors have been related to sound music the superficiality has been quite apparent. It is significant that the names of these "inventors" are not found among the experimental psychologists and other investigators who are unearthing information that may some day form the foundation of an art of mobile color.

In 1869 J. S. MacDonald in a book entitled "Sound and Color," attempted to relate sounds and colors by affixing to the "seven colors of the rainbow" the "seven notes in the musical scale." He hoped that by such a relation they "might prove to be perfectly analogous in their relative properties and effects either in single sequence, or in combination." His object was to make practical use of the principles of musical harmony in painting, or in the association of colors in matters of dress or decoration. Painting as an art is on a par with music, but the latter as a science is certainly in advance of the fine arts

Rimington, a few years ago, in a book entitled "Color-Music," repeatedly compares colors and sounds owing to the fact that both "are due to vibrations which stimulate the optic and aural nerve respectively." He further states that "This in itself is remarkable as showing the similarity of the action of sound and color upon us." He presents other "similarities" but in fairness it should be noted that he states that too much weight should not be given to them. Nevertheless, owing to the repeated citations by Rimington of these "similarities," one concludes that they influence him considerably in developing his so-called "color-organ." The same general criticism applies to MacDonald's theory, as well as to practically all of the writings upon the relation of colors and music.

There is no physical relation between sounds and colors. Sounds are transmitted by waves in a *material* medium, as proved by many experiments. Light rays are *supposed* by many to be transmitted by a *hypothetical* medium called the ether, but scientists do not agree as to the *existence* of an ether. Furthermore, the two kinds of wave motion that are used, for convenience, to represent sound and light respectively are *necessarily* different, because the former can not be polarized while the latter can be. These few fundamental differences are sufficient to prove the futility of any claims that sounds and colors are produced in similar ways.

Now let us consider the perceiving organs. The ear is analytical because a musical chord can be analyzed into its components. This is not true of the eye; that is, the eye is a synthetic instrument incapable of analyzing a color into its components. Many colors can be produced by various mixtures of spectral colors. For instance a spectral yellow can be matched by a mixture of red and green spectral lights. The eye can not distinguish between these two yellows. This difference in two organs must necessarily influence the choice of a fundamental mode of producing "color music."

Recently a musical composition by A. Scriabine entitled "Prometheus" was rendered by a symphony orchestra (as described in the *Scientific American* April 10, 1915, p. 343) with the accompaniment of colors according to the "Luce" part as written by the composer for the "Clavier a lumieres." No clue is given in the musical score regarding the colors represented by the notes in the "Luce" part, or the manner in which a "color chord" is to be played—whether by juxtaposition or superposition. The latter is of fundamental importance inasmuch as the eye is not analytical, and a mixture of the colors of a "color chord" results in a single hue. Some of those responsible for the rendition of this music with the color accompaniment had at different times, previous to the final presentation, accepted both the Rimington scale and the Scriabine code (the latter having been discovered after the experiments on the "color instrument" were well under way) as being properly related to the music. These codes as shown in the table are quite different. In fact the colors represented by certain notes are sometimes actually complementary. The original acceptance of the Rimington scale, in the absence of Scriabine's code, as being adapted to the music, and the final acceptance of the latter code, which was used in the public presentation, shows that at the present time there is no definite relation between colors and music, even in the minds of artistic interpreters of music. It must not be assumed that the colors in the table bear any absolute relation to the corresponding notes, for they do not. Those familiar with the science of color would hardly consider it probable that a composer of music would hold the key to "color-music" when they freely acknowledge their helplessness in definitely relating colors and musical sounds. We are yet quite ignorant of the philosophy of the representative or allegorical power of music, and our knowledge of a similar power of colors is almost infinitely less. Everything pointed to a failure in the rendition of "Prometheus" with the accompaniment of colors, and if one is to agree with the critics, after allowing for a considerable degree of conservatism and inertia, the relation of the colors and musical sounds was worse than indefinite, distracting, and unsatisfactory. Considering that the experimental work has not yet been done which should form a basis for expression and arousing emotion by means of colors, no other outcome of superficially [illegible] colors to sound music could have been expected. Even though this be a progressive age it is not likely that color music can evolve, in an acceptable form, from the [illegible] of any one person. The mechanical [illegible] of the color instrument was [illegible] [illegible] than many flashing signs on Broadway, [illegible] al as many color mixing devices used [illegible] menters in color [illegible].

While it appears that [illegible] evolve from [illegible]

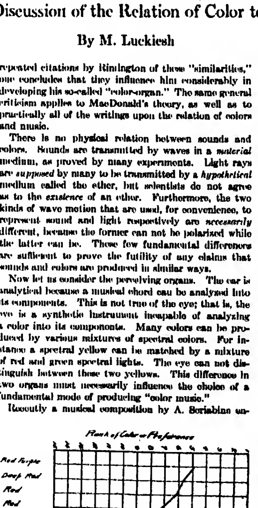
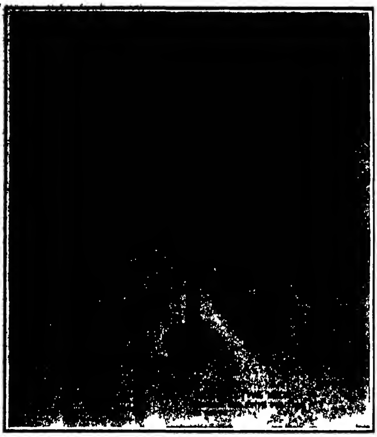


Diagram showing results of experiments with fifteen observers.



The mechanism of the color piano used in the production of Scriabines' "Prometheus" at Carnegie Hall, New York.

"emotive value" of colors of simultaneous and successive contrasts in brightness and hue and of rhythmic sequences in hues, tints and shades it is interesting also to experiment with colors in relation to music However, a safe elementary procedure in the latter experiment is to use colored light merely to provide the "atmosphere," and gradually to introduce the element of varied intensity and possibly rhythm Certainly it is far less presumptuous to use color in this manner in the absence of experimental data than to attempt to play a 'tune' in colors as a part of a musical score In providing "atmosphere" for a particular motif such superficial associational relations as blue-green for rippling water and orange-red for fire (because artists paint them thus), are insufficient It is the deeper emotional relation that is desired which cannot be determined with certainty without many careful experiments

In developing an independent art of mobile color what procedure shall be adopted? Certainly the fundamental experiments will be found in the realm of psychology The aim of the modern artist is not totally unrelated to the subject, and a group of such artists perhaps would form a most interesting audience for these experiments The new movement in the theater which is striving for harmony in action, lighting and setting is not wholly unrelated to the subject under consideration The study of the evolution of sound music is likewise profitable and encouraging A thought that naturally comes to us is this Is there anything in Nature that suggests color music? Perhaps scenes full of color may be suggestive of the "atmosphere" colors for musical compositions. Perhaps if the cycle of appearances of such a scene throughout a day were compressed into a period of five minutes it might suggest what a composition in the art of mobile color would be like When one begins the experimental work he is appalled at the immensity of the work to be done The available psychological literature yields some interesting information Some work on affection pertaining to colors has been done; however, the work which eventually will form a definite basis for developing an art of mobile color, has hardly been begun. As an illustration of the character of the elementary experiments to be performed the mean results obtained from fifteen observers on the preferences for fifteen colors are given in the accompanying diagram. These colors ranged throughout the spectrum and included purples. Nearly all the colors were as saturated (pure) as possible. The fifteen colors, each four inches square, were placed upon a white surface as far apart as possible The subjects were asked to survey the colors and pick them out in the order of their preference. They were further instructed to isolate the colors, as far as possible from everything, and choose them for color's sake alone. The mean rank of the [illegible] were as [illegible], the lemon yellow ranking last. It [illegible] there is a definiteness and consistency in [illegible] of these observers for the mean rank [illegible] is not far from last. [illegible] were only 10 colors from which to choose The most saturated (pure) colors were preferred and those were near the ends of the spectrum and also included the purples These results agree in general with those obtained by Cohn Bradford Titchener and others although these various investigators used different methods There is some evidence that subjects who are less capable of isolating the colors that is, more inclined to associate them with other experiences prefer the tints and shades Space will not permit of a detailed account of such experiments but the foregoing is cited as one of the simple means of attacking the problems to be solved before the art of mobile color can be supplied with a foundation

All the known principles of harmony and contrast of colors are available for use by the pioneer in the art of mobile color The 'emotive value' of various hues tints and shades of simultaneous and successive contrasts in hue and brightness and of rhythmic sequences in hue and brightness must be determined While a color may be most highly preferred among a large number of colors the emotive value' of this color is perhaps rather low as compared with many other experiences For instance a deep blue color may be distinctly more preferred than any other color in a certain group yet it can hardly be compared in emotive value to a song by one of our operatic artists As Titchener states when compared in pleasantness with a good dinner or the scent of a flower the color patch will seem practically indifferent Of course the results of impressions are only relative and there is perhaps sufficient emotive value in colors alone to bring success to color music However the foregoing point is of interest in combining colors and sound music. Certainly a 'color instrument can not compete with a symphony orchestra, which leads to the tentative conclusion that color in such a relation should be subordinated to the role of merely providing "atmosphere A color instrument of definite form is conspicuous in its feebleness when in the midst of a symphony orchestra Such a criticism applies to the recent rendition of Prometheus

The mechanical construction of experimental apparatus for studying color phrases' is simple Two general methods must be employed at first In one the various colors composing a color chord' are separated physically by playing them on different parts of a white screen thus introducing the factor of harmony and overcoming the lack of analytic ability of the eye In the other the component colors of a color chord are mixed by superposition Obviously in the latter case harmony is limited to the presentation of colors successively and the predominant factor in composing color music to be rendered by such an instrument would be that of color-mixture In the former case the predominant factor would be that of the harmony of juxtaposed colors In both procedures the element of rhythm and variation in brightness can be introduced Both types of instruments have been experimented with by the writer, but no great amount of decisive data have been obtained

The object of this article has been to point out briefly some of the errors of the past, and to suggest the procedure for constructive study with the hope that it will lead to a definite art of mobile color At present there is no art of mobile color, meager constructive data are available there have been hardly more than superficial attempts made to present it psychological studies must be relied upon to point the way toward its development the field is worthy of cultivation there are definite problems that must be studied in order to obtain foundation material for building up an art of mobile color

COLOR CODES

	MacDonald 1869)	Rimington (1911)	Scriabine 1911)
C	Red	Deep Red	Red
C#		Crimson	Violet
D	Orange	Orange-Crimson	Yellow
D#		Orange	Glint of Steel
E	Yellow	Yellow	Pearly blue and shimmer of moonshine
F	Green	Yellow Green	Deep red
F#		Green	Bright blue
G	Blue	Bluish green	Rosy orange
G#		Blue green	Purple
A	Indigo	Indigo	Green
A#		Deep blue	Glint of Steel
B	Violet	Violet	Pearly blue and shimmer of moonshine
C	Red	Invisible	

Radium Treatment of Cancer

The American Society for the Control of Cancer fears that exaggerated ideas of the power of radium in the treatment of cancer may result from the recent publicity given to this agent in the daily press It appears highly important at the present time that the limitations of radium in the control of cancer should be emphasized as well as its favorable effects in certain cases Otherwise the familiar story of new hopes destined only to disappointment will again be recorded at the expense of many unfortunate sufferers

The curative effects of radium are practically limited to-day to superficial cancers of the skin to superficial growths of mucous membrane which are not true cancers and to some deeper lying tumors or bone etc which are not very malignant The problem of the institutional treatment of advanced inoperable cancer is still untouched by any method yet devised or likely to be devised for administering radium Even among the so-called radium cures it still remains to be determined in many cases whether the favorable result is permanent or is to be followed sooner or later by the usual recurrence The most competent surgeons do not dare to pronounce a case cured until five years have elapsed after an apparently successful operation The same test must be applied before we can finally determine the real value of radium

It should be emphasized especially that radium can not at present exert any permanent benefit on generalized cancer and since cancer in a very large proportion of cases is widely disseminated in the body early in the course of the disease this entire group of cases can expect no important relief from radium Another large group of cancers is comparatively inaccessible to the application of radium so that the ultimate course of the disease is not affected although certain portions of the tumor may be reduced in size Again many forms of cancer although localized and accessible to radium grow very rapidly and resist the curative action of this agent so that no real benefit can be expected from its use

The best results of radium therapy can be secured only when comparatively large amounts are available for use and the present limited world's supply of this metal places it out of reach of the great majority of patients It is to be feared that much harm may result from undue reliance upon small quantities of low grade radium when other methods of treatment would be more effective

Evidence of the possible extent of popular misconception on this subject is found in a pathetic letter recently received at the New York Health Department from a sufferer in California who had somehow obtained the impression that the United States Government was about to purchase large quantities of radium from abroad Assuming that the New York city physician would have a plentiful supply the writer asked that some be sent to him C O D without delay ing to advise him as to the cost

Under the term 'cancer' are commonly grouped several diseases which differ widely in nature causation and courses, and in their response to radium It requires both skill and experience to determine just what type of cancer one has to deal with as well as the advisability of using radium Hence it is extremely difficult to formulate an accurate statement of the true positions of radium therapy but it is quite clear that the exploitation of this remedy as a cure of cancer in general is to be deprecated.

Floor Surfaces in Fireproof Buildings

Recommendations in Regard to Material and Methods of Construction

By Sanford E. Thompson

In fireproof construction, whether it be office building, factory, or institution, the question of the type of floor surface to select and the method of construction to adopt is a most important one. The constant tread and shuffling of feet cause a friction that it is difficult to withstand without serious wear.

From the construction standpoint, in a non-combustible structure a cement surface is in keeping with the rest of the building and is naturally the first considered. In many instances the cement concrete or granolithic floor has proved extremely satisfactory, while in others because of the use of improper constituents, of inexpert construction or of its selection for places to which it is not adapted, it has proved a disappointment. As a matter of fact, no one type of floor surface is adapted to all conditions, while for any type that is properly selected, the choosing of the material and the manner of the construction will govern to a large extent the durability of the surface.

It is the purpose of this paper to discuss briefly the different kinds of floor surfaces, and to compare their various qualities, their cost, and their adaptability to specific conditions. This is followed by a more detailed treatment of the methods of constructing the concrete or granolithic surface which have produced satisfactory results.

An engineer in consulting practice is called upon frequently not only to design and construct but to investigate defective construction and also to make special tests for the determination of the best methods to employ in a particular case. In this paper are embraced not only the results of experience in floor construction and repairs, especially as they relate to granolithic surfaces, but also the conclusions derived from special tests and investigations made in connection with services as consultant on the superstructure of the New Technology buildings in Cambridge.

The selection of the type of floor is dependent on the character of the structure, the nature of the wear, and the architectural appearance. Every building must be considered by itself. Suggestions for the type of surface to select are covered in the following pages. As a preliminary guide, the material suitable for different conditions may be given as:

Basements. Granolithic finish with troweled surface made with approved materials and workmanship.

Factory Floors. Granolithic finish with troweled surface, hardwood.

Machine Shops. Granolithic finish with troweled surface, hardwood on substantial base.

Ground Floors for Heavy Manufacturing. Wood block, granolithic.

Warehouses. Granolithic with troweled surface, asphalt composition, hardwood.

Offices. Hardwood, linoleum on concrete, magnesium composition.

Corridors and Halls for institutions and office buildings: Terrazzo, granolithic finish with ground surface.

Entrance Pavilions. Terrazzo, mosaic, tile, natural stone.

Class Rooms, Lecture Rooms, and Drawing Rooms. Linoleum on concrete, granolithic with ground surface, hardwood, magnesium composition.

Laboratories. Granolithic with troweled surface, magnesium composition, tile, hardwood.

Lavatories. Terrazzo, granolithic finish with ground surface, tile.

The above selections are given in the order in which choice might be made for the average building or room of each class.

CHARACTERISTICS OF FLOOR SURFACES

Granolithic Troweled. As ordinarily laid in buildings granolithic or concrete surfaces are subject to dusting and under heavy traffic, such as trucking, are liable to serious wear. On the other hand, experience with first class construction and tests of actual floors shows that it is possible, by proper selection of the aggregates and expert workmanship, to reduce the dusting to an insignificant amount and to produce a surface hard enough to stand even severe wear.

For factory floors, notwithstanding many cases of inferior construction, the use of granolithic is largely increasing. It is becoming recognized that the durability of granolithic is in a very large measure dependent upon the sand or other aggregates used in the construction and the methods of laying it.

The chief objection to concrete or granolithic surfaces for offices, drafting rooms, class rooms, and certain laboratories, is that it is dull in appearance, hard on the feet for men standing all day, tends to break tools dropped upon it, and is not adapted to attaching seats and other furniture readily, especially where they have to be shifted occasionally. In certain colleges, however, concrete surfaces are used widely and highly recommended. At Bowdoin and at the University of Wisconsin it is considered satisfactory for all purposes. At the University of Missouri the newer buildings are all being built with granolithic surfaces. In some colleges granolithic is being satisfactorily used for corridors. Most of the colleges favor granolithic for chemical, mining, and mechanical laboratories. The Leland Stanford, Jr., University states that in the mechanical and engineering laboratories the men complain of hardness and coldness, requiring wood platforms in many places. In this university, however, granolithic has been used in the chemical laboratories for fifteen years with excellent satisfaction. It should be noted, further, that in the mechanical and engineering laboratories the floor rests directly on the ground, while in the chemical laboratory there is a warm room or basement underneath. The life of a well laid granolithic surface under foot traffic is practically permanent.

Granolithic with Ground Surface. Experimental surfaces together with laboratory tests made as a check, show that a pleasing surface, approaching terrazzo in appearance and fully as durable under foot traffic, can be obtained by placing granolithic with scarcely any troweling, and then grinding the surface just enough to expose the grains of sand and stone. The grains which show are finer than in terrazzo and darker colored. The appearance, however, is pleasing. Removal of the scum takes away the monotony of the plain gray cement surface, since this is relieved by the various colors of the sand and stone. A glossy effect can be produced if desired by the grinding which permits of easy cleaning and gives a surface suitable even for a lavatory at much less cost than tile or terrazzo. Still further to give variety to the appearance tile can be placed in patterns or as a border.

The University of Missouri, which refers to the dust from granolithic floors, believes that this difficulty would be solved by grinding the surface instead of troweling. Specifications giving the method of laying the concrete granolithic and grinding it are presented at the end of this paper. From observations of the time required for grinding the surfaces and allowing amply for delays the extra cost for grinding is estimated not to exceed 3 cents per square foot of surface area.

Linoleum. The hardness and noise characteristic of granolithic finish are overcome by covering the surface with Battleship linoleum. In the few colleges where this has been adopted they are very enthusiastic over the results. In other places, such as offices, the same type of construction meets with a great deal of favor. At the University of Chicago cork carpets are used, which answer a similar purpose.

Linoleum is laid on a concrete surface, which need not be brought to a fine finish, and therefore can be completed at the time the base concrete is laid and at a low cost. Any marring of the surface or sudden rains will not affect its use for the linoleum finish.

The linoleum should be stuck firmly to the granolithic surface and preferably a cove base should be run around the room and sills provided at entrances so that the surface of the granolithic will be flush. In this way the edges are prevented from fraying. The life of first-class quality Battleship linoleum, if edges are not frayed, is probably from fifteen to thirty years, depending upon the amount of travel. These ages are estimated from records of linoleum now in use.

Linoleum, after allowing for the better finish required on the concrete costs substantially the same as a single floor of birch or maple, but it is noiseless, more uniform in appearance, and requires less labor for maintenance in good condition. Its superiority to wood is indicated by the fact that wood floors are frequently covered with linoleum.

Hardwood Floors. Floors of maple, birch, beech, oak, or long leafed Southern pine are used most largely for offices, class rooms, or lecture rooms, and in many of the older colleges for laboratories and halls. A wood surface, however, is not usually considered entirely satisfactory either in general appearance or in wearing qualities. If one passes from a corridor with a granolithic, terrazzo, or tile floor, into a room or auditorium having a wood floor, there is a marked effect of inferiority and cheapness. There is just as much danger of poor materials and workmanship with wood as with other kinds of floors. Unless the greatest care is taken in selection of materials and workmanship, they are liable to shrink or swell and sometimes to squeak under foot. If at all hollow underneath, they are more noisy than a concrete surface. The floors of the New Grand Central office buildings are an example of this.

For corridors, wood is being largely superseded by granolithic, terrazzo, or tile. For laboratories other materials are being substituted for wood in most of the newer structures, although wood is occasionally preferred, especially for physical laboratories and for laboratories where men stand for long periods. The linoleum on concrete will overcome practically all the objections that are made to wood floors, with a cost substantially the same.

There are various methods of laying hardwood floors. For class rooms a single thickness of maple or birch nailed to sleepers with cinder concrete between should be satisfactory. Another type of construction is to use patented metal screeds embedded in the base concrete, and nail the floor boards to splines in the screeds. For rooms subjected to heavy traffic, 2-inch or 2½ inch plank may be placed underneath the hardwood floor.

Of all the different materials, oak is the most expensive and the finest in appearance at the beginning, but under heavy traffic is more liable to splinter than the finer grained woods. Georgia pine, if of best quality, makes a durable floor, and is preferable to the finer grained woods in wet places, as it does not swell and warp so badly. It is less durable, however, and therefore not recommended for the greatest permanence in rooms such as class and lecture rooms. Maple, birch, and beech all make good floor material. These are usually laid in strips ⅞ inch thick by 2¼ inches wide. The quality varies largely, ranging in cost from $32 to $75 per 1,000.

Terrazzo. Terrazzo is made by spreading upon the base concrete a mixture of neat cement and marble chips and grinding the surface to a depth sufficient to cut into stones and expose them on their largest diameters. Marble, sometimes white and sometimes colored, is used, and since no sand is employed the particles may be of fairly uniform size. The joints between the particles being of neat cement are hard and even more durable than the pieces of the marble themselves. Large pieces of marble, from ¾ inch to 1 inch in diameter, give a more distinctive floor but cost more than a floor of the smaller stones, from ¼ inch to ½ inch in diameter, because the large stones require much more grinding to get down to the large diameters of the particles. There is more tendency to crack than in a good granolithic properly bonded to the base, but if laid with the best workmanship, this cracking is reduced to a minimum. Terrazzo is largely used, especially in the newer office buildings and in institutions, for corridors and halls. It also is satisfactory for lavatories, although more expensive than granolithic. It appears from our investigation that for both of these uses concrete with a ground surface can be substituted at less cost and with satisfactory results. In certain cases objection—which applies also to any hard material like granolithic or tile—is raised to terrazzo because of the noise, and even corridors are covered with linoleum or similar material.

Marble Mosaic. Mosaic consists of small squares of marble laid on the cement bed, something like terrazzo. Surfaces are ground enough to make all pieces true and level. The price of mosaic is too high to be considered for large areas and in many cases the pieces of marble pull out from the surface. Mosaic is suitable in certain cases for an ornamental border which is not subject to wear.

Magnesium Composition. When laid with great care, composition is a satisfactory and durable material. Floors six or eight years old have been examined and show satisfactory wear. The work must be done by a responsible firm with a suitable guarantee bond, because even with the greatest care the work is occasionally imperfect. The imperfections, however, are apt to show within the first year of service. Composition is more resilient than granolithic, so that there are less complaints of hardness. It is nearly, but not quite, as noisy. Furniture can be screwed directly to the composition. Composition has not yet been used to a great extent in colleges. The floors of Cooper Union in New York city are many of them covered with this material and the results have been satisfactory. It is definitely the ...

* From a paper read before the American Society of Mechanical Engineers.

tain school laboratories, such as physical and biological.

Asphalt Composition. Asphalt composition is suitable for certain places where no heavy tools or machines are liable to press into the soft surface. It is resilient and easy to walk and stand upon. The color is not pleasing, being a dead black. In a few colleges it has been used satisfactorily for chemical laboratories. At Harvard, for example, asphalt mastic on top of wood has been in satisfactory use for many years. Johns Hopkins considered this material for their new chemical laboratories but abandoned it because of its viscous properties, substituting granolithic finish, which has proved satisfactory.

Tiles. Tiles of various colors is an excellent material for corridors, lavatories, and even for laboratories, but is too expensive to use except where required for architectural treatment. There are various types and qualities of tile, ranging from quarry tile to cork and rubber tile. All of them, however, are expensive.

Wood Block. Wood block may be suitable in certain cases for a basement floor having severe usage. In the University of Cincinnati wood block is used in the mechanical and electrical testing laboratories and appears to be satisfactory.

TESTS AND INVESTIGATIONS OF GRANOLITHIC FLOORS.

The material used most largely for floor surfaces in factory construction and also to a considerable extent on other structures is what is termed a granolithic surface. This, as generally understood, is a layer of mortar or concrete from ½ inch to 2 inches thick, usually about 1 inch on top of the concrete slab and bonded to it. Although granolithic or concrete floors are so widely employed, neither the materials nor the methods of construction are standardized and scarcely two contractors or engineers adopt the same methods. Moreover, the materials available in a given locality largely affect the choice.

In order to compare the materials, that is, the aggregates, available for new Technology, and to determine the best proportions and methods of laying these materials, a series of sample surface were laid at the factory of the Simplex Wire and Cable Company, in Cambridge. Also, comparative tests were made with similar materials in other locations. A few preliminary laboratory tests were carried through, and certain tests to determine the best method of bonding a new granolithic surface to a hardened concrete base. As a result of these experiments, the following recommendations are made for the granolithic finish of floors for which this material is to be used. The conclusions apply also to structures in general.

Materials. The various aggregates used in the tests include three kinds of sand mixed as mortars in different proportions, and combinations of these sands with samples of different granites and traps. One or two sections were also laid with a patented compound.

Careful examination and comparisons of the various sections of slab with reference to hardness and appearance led to the selection of Plum Island sand, which should be specified to have not more than 10 per cent of its grains pass a sieve having 50 meshes to the linear inch, and not more than 2 per cent pass a sieve having 100 meshes to the linear inch; and crushed granite of a size which has passed the ¾-inch screen in a crusher plant and been caught on the $\frac{1}{16}$-inch screen.

As a result of this selection, a slab of considerable area was laid at a later date at the Simplex factory with the selected materials and proportions, and in a position where it would receive rather hard usage. The Simplex Company have recently advised us that they consider this slab the best piece of granolithic that has been laid in the factory.

Proportions. Different proportions of the materials were employed in the various sample sections, each of which was about 2 feet wide by 3 feet long. The principal proportions tested were 1:2, with sand alone; 1:1½ with sand alone; 1:1:1¼ with sand and fine crushed stone; 1:1:1½ with the same materials, and 1:¾:1¼. As a result the proportions selected as best are one part cement to ¾ part Plum Island sand to 1¼ parts crushed granite.

Method of Laying Granolithic. Instead of using a soft, flowing mixture, the best results were obtained by using a fairly stiff mixture, stiff enough to be rammed in place by a square-faced rammer, which would bring the mortar readily to the surface. In this way the surface skin is thinner, there is less liability to dust, and the body of the concrete, which is of a better quality than with a wetter mix, is reached with comparatively little wear, so that the dusting does not continue.

Treatment of Surfaces. Dusting is temporarily overcome by paint, but this is always unsatisfactory because it wears off under ordinary travel, and if the concrete is not of the best quality it then begins to dust.

Grinding Surfaces of Granolithic. Objections to granolithic finish are dusting of the surface, the dead gray color, and the liability of local defects. Experiments show that these can be overcome by grinding the surfaces with a carborundum machine. This method was followed on a section of slab at the Simplex Wire and Cable Company.

The general plan adopted is similar to that used with terrazzo finish. Instead, however, of grinding off a considerable thickness and thus entailing a large expense per square foot, only a very thin layer is taken off so as to show the grains of sand and the pieces of coarser aggregate. With this treatment, the surface is of a varied texture, and shows the various colored grains, and permits of different effects by using aggregates of different colors. While the effect is not so conspicuous as the terrazzo, the surface is of a quieter tone, and should be satisfactory for ordinary corridors and halls. The grinding renders the surface more glossy and denser, so that it is possible to use this treatment with good results in a lavatory or other places where frequent washing and cleaning is required. To produce a more ornamental effect, borders or patterns of tile may be placed in the concrete.

Bond of Granolithic to Base Concrete. A perfect bond between the granolithic and the base concrete is obtained most easily by placing the granolithic before the base concrete has reached its set. Surfaces thus laid are liable to injury from the workmen who have to go upon them before they have hardened thoroughly, and occasionally an unexpected shower will roughen the surface in such a way that it is very difficult to repair. To determine the best method of bonding, one which would give thorough assurance of perfect adhesion, tests were made and then tried out in the field on a large concrete building.

Laboratory tests were made on bonding new mortar to an old concrete surface, using various methods of treatment of surface, including acid treatment, roughening, and no surface treatment whatever. As bonding material, neat cement was used in different conditions of plasticity, also certain patented compounds. As a result of these tests and experience in the field, a roughened surface of the old concrete, with neat cement paste brushed in, is recommended as an effective method to produce a positive bond. It was shown in the tests that with a proper neat cement bond on a roughened surface the break under tension was frequently through the concrete rather than at the joint.

Preparing Concrete Base for other Surface Materials. If some other material than granolithic is used for the wearing surface, the base concrete must be left in a condition satisfactory for placing the surface. For most materials, such as hardwood finish, composition, asphalt and similar treatments, the surface of the base must be brought more nearly level than where granolithic is used. This can be accomplished by very careful screeding of the surface, troweling of rough places, and filling holes made by footprints before the concrete has hardened.

For linoleum, a real granolithic is not required, but the surface must be level and true. This should be accomplished by spreading a thin layer of mortar before the base concrete is set, but this need not be of the very best quality of granolithic unless with the object of using portions of the floor without linoleum. This thickness of the mortar may be ½ inch to ¾ inch. This should be troweled at the proper periods, but with less care than for a granolithic that is to be used as wearing surface. Some form of cove base around the walls is advantageous to use with the linoleum.

High-Speed Engines*

FOR the last four or five years we have been producing in some of our factories on the other side high-speed engines which will run successfully in touring automobiles without any more trouble than the ordinary slow-speed engines. In fact, five years ago the company I was connected with were in a position to give a three years' guarantee with their automobiles, the engines of which ran at a maximum speed of about 2,500 to 2,000 revolutions per minute. Within the last two or three years we have been producing engines which have been developing maximum power at 2,400 revolutions per minute, and these have accelerated to 2,800 revolutions per minute on the slightest down grade. These particular automobiles have not only been successful in the British Isles, but have been highly satisfactory and successful in our colonies, such as Australia, New Zealand, etc., where the roads are, I think, pretty much on a par with American roads. In fact, just before leaving England I inspected a report from one of my assistants who was in Australia looking into the matter. His report, as well as the agent's report on the behavior of automobiles there, not only of our own production but of high-speed-engined cars produced by other firms, was to the effect that they were entirely satisfactory.

I am stating these points because in discussing them with some of the engineers here I have found that quite an erroneous idea seems to exist regarding the durability of the high-speed engine fitted into a moderately light chassis. The chassis which these engines are called upon to pull are not light, being in most cases of about the same weight as some of the modern chassis here. These chassis stand up not only in Britain but also in the colonies. A horse-power represents 33,000 foot-pounds of work, whether it is developed in Britain or in America, and if the required horse-power can be obtained with a smaller engine, greater economy will result. As an example of what has been done, I have designed a four-cylinder engine of 2 11/16-inch bore and 5-inch stroke, which developed 30 brake-horse-power at 2,600 revolutions per minute. It was fitted to a 110-inch wheelbase chassis weighing 1,680 pounds. This automobile could pull on top gear at 10 miles per hour on a very decent grade, in practically the same manner as a six-cylinder automobile with an engine of 3¼-inch bore and 5-inch stroke. The wheelbase of the six was 126 inches and the chassis weight about 2,632 pounds. Both chassis carried a load of driver and one passenger, plus a weight of 896 pounds. The small automobile was only three or four miles an hour slower than the large one. Obviously, the small engine was more efficient and developed a much higher mean effective pressure than the larger engine.

Undoubtedly, the most efficient valve mechanism which can be designed is the overhead system, because the combustion chamber is more perfect and presents less cooling surface to a given volume of gas than any other arrangement. This arrangement has, however, an inclination to become noisy, as, due to the inertia of the valve gear, which is undoubtedly greater than with any other type and naturally requires correspondingly stronger springs to prevent valve chatter, the rocker pins, etc., soon develop a certain amount of play or wear, especially if the engine is of the efficient high-speed type. If the engine is not of this type, there is no necessity for overhead valves.

One can get highly satisfactory results with the exhaust valve in the orthodox position and the inlet overhead. With this arrangement about 15 to 25 per cent more charge can enter the cylinders for a given size of valve than with the L-head type of motor. The power of a motor depends largely upon its volumetric efficiency.

I have been astonished to find how many of the engineers on this side still favor the T-head type of motor. I have found this arrangement to be the least efficient on record, it being necessary in order to get even moderate efficiency to use a two-spark magneto with spark plugs on either side of the combustion chamber. I have proved this contention more than once. It has also been proven by the fact that two spark plugs make very little difference in the L-head type of motor, no matter in what position they are placed.

For ordinary sizes of racing motors it is, in my opinion, entirely unnecessary to fit multiple valves unless it is desired to run the engine somewhere about 5,000 revolutions per minute, or unless the bore of the cylinder be so large and the stroke so long that two ordinary valves would be entirely too large. Regarding the design of valves and valve gear generally, I would say that lately I took part in some experiments with an engine running at 4,000 revolutions per minute and developing power at that speed, the valves being side-by-side in the conventional L-headed manner. The results were certainly astonishing.

I have been using in my own automobile an engine which developed full power at 3,000 revolutions per minute, the bore being 3 1/8 inch and the stroke 5 1/8 inch. The wheelbase of the chassis was about 126 inches and the weight about 1,900 pounds. This automobile could touch about 70 miles per hour in touring trim, with open torpedo body but no wind screen. The acceleration was good from about 7 miles per hour an hour on top gear.

* Paper read by D. McCall White and published in the S. A. E. Bulletin.

Railway Rail Production and Failures

BULLETIN No. 170 of the American Railway Engineering Association dealt with statistics of rail failures furnished to the American Railway Association by various, but not all, of the railways in the United States and Canada. These show that during the year ended October 31st, 1913, there were 63,472 tons rolled on the Bessemer process and 703,557 tons by the open-hearth process. In 1909, when about the same total tonnage was rolled, the figures were 432,155 for Bessemer and 461,261 for open-hearth. The failures in 1911—the years 1912 and 1913 are too recent to afford any conclusions as to failures—were 37.3 per 10,000 tons of open-hearth rails and 94.2 per 10,000 tons of Bessemer rails, which, taking the open-hearth failures as 100 per cent, means 252 per cent for the Bessemer. In 1909 the open-hearth rails had 100 failures per 10,000 tons and the Bessemer 212.4, which, again taking the open-hearth failures as 100 per cent, gives 105 per cent for the Bessemer. The percentages in favor of open-hearth rails have increased year by year, which, the report says, suggests the thought that there were faulty practices in the early rollings of open-hearth rails since improved upon.

Automobile Lubrication—II*

How to Test, and How to Use Various Classes of Oils and Greases

By C W Stratford

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No 2059, Page 393, June 19, 1915

CONDITIONS UNDER WHICH MOTOR OILS WORK

These may be treated under three headings (1) Division of lubricating system (2) Operating temperatures of motor parts (3) Requisite physical properties and their effect upon motor operation

Division of Lubricating Systems —A thorough analysis of the lubricating systems of automobile motors with all their peculiarities of design in connection with exhaustive tests made with oils in each shows that practically every lubricating system in use to-day can be included in the following distinct types

(1) Full Splash	(6) Separate Force Feed
(2) Splash with Circulating Pump	(7) Force Feed
(3) Pump Over and Splash	(8) Full Force Feed
(4) Force Feed and Splash	(9) Knight Slide Valve Motor
(5) Pump Over	(10) Oil Fed with Fuel

The reason for choosing such a fixed number of lubricating systems is to facilitate their proper classification and because of the effect which the details of these lubricating systems exert upon the flow of oil to the moving parts Insofar as the principles involved go lubricating systems without exception can be divided into two general groups Circulating systems and All loss systems By all loss system is meant a lubricating system in which oil is fed directly into the crankcase or through the bearings into the crankcase from an outside source Oil thus fed into the case never returns to its source In all loss systems the lubrication of the parts in contact is accomplished by (a) splash only from the connecting rod ends and by (b) oil under pressure as well as by splash from the connecting rod ends In motors employing all loss systems oil is filled up to a fixed level in the crankcase The lubrication of all parts is then made continuous by splash and by feeding oil from an auxiliary source into the crankcase where it is consumed at or about the same rate as the feed All loss systems are however much less fool proof in many ways than are the circulating There is a possibility with the former of feeding an excess of oil into the crank case which may cause a rapid carbon deposit in the cylinders or on the other hand of feeding too little oil thereby causing unduly rapid wear or perhaps serious injury to the parts from want of lubrication

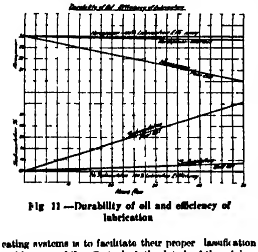


Fig 11 —Durability of oil and efficiency of lubrication

By circulating system is meant a lubricating system in which a quantity of oil is filled to a fixed level into the crankcase sump whence it is circulated by some type of pump or by the flywheel to all parts requiring lubrication In circulating systems the oil is applied to the moving parts by (a) splash alone from the connecting-rod ends or by (b) pressure and splash from the connecting rod ends A drain pocket or cavity should be provided at the lowest part of the crankcase sump in circulating systems so that all metallic sediment carbon heavy carbonaceous or foreign matter will settle and not re-enter the circulating pump Fine mesh metallic screens are regularly fitted between the main crankcase and the oil sump below or over the inlet side of the circulating pump as a positive means of separating solid matter, cotter pins nuts and wrenches from the lubricating oil.

Before leaving the subject of lubricating systems, I wish to state that during my own experience as a designer of internal combustion engines I have frequently been called upon to solve many vexatious and baffling problems most of which had to do with the proper form and arrangement of the lower crankcase oil sump and its accessories Very careful attention here to details invariably pays in the long run The very success or failure of a motor in the hands of a careless public may depend wholly upon their excellence

* A paper presented at the semi-annual meeting of the Society of Automobile Engineers, June 14th, 1915.

OPERATING TEMPERATURES

Automobile motor oils are exposed continuously to much higher temperatures in an internal combustion engine than they were in the heat test already mentioned Especially is this true within the explosion chambers upon the upper surfaces of the cylinder walls and upon the lower surfaces of the piston heads For clearness let us examine only the functions performed by the oil and the changes which it undergoes above and below the piston

Oil for the lubrication of pistons and cylinders is splashed on the lower cylinder walls and from there it is carried upward and spread over the cylinder wall surface by the pistons and piston rings A certain quantity as well is thrown off the pistons on their ascending stroke and projected onto the entire explosion chamber walls If the latter quantity is small and the fuel mixture is set on the lean side it will be flashed off, leaving no appreciable deposit But when an overabundance is thrown up the heat of explosion can only vaporize the exposed surface or outer layers so to speak of the oil film because of its poor heat conductivity and blow it out with the exhaust gases in the form of smoke leaving behind heavy end-products of destructive distillation These are rapidly reduced by the intense heat of open throttle explosions into a cumulative incrustation called carbon deposit in common parlance The actual free carbon content of this carbon deposit may vary from less than 1 to as high as 75 per cent Other constituents present are metal oxides mostly iron from a trace to approximately 5 per cent large percentages of inactive earthy matter (road dust) and solid black carbonaceous or asphaltic compounds according to the oil used An analysis of crankcase sediment taken from a laboratory motor showed free carbon under 2 per cent metal dust less than 1 per cent the remainder being nearly equal quantities of carbonaceous matter (1) soluble in naptha and (2) soluble in carbon disulphid And the analysis of deposit taken from the crankcase side of the piston heads showed approximately the same percentage of the above constituents excepting a slight increase in free carbon

Given an oil of good quality carbon deposits resulting from its use up to the point where trouble occurs can and should be easily avoided between annual overhauls by the manufacturer's proper design of motor parts While it is a fact that much can be done toward the suppression of mechanical defects omissions of design and carbon deposits accruing therefrom by correct oil specifications to suit the case in hand it is decidedly unfair to suppose that oil alone can satisfactorily replace leaky piston rings or to burden motor oil with a more exacting task in the cylinders than that of good lubrication with its helpful seal against slight gas leakage

Below the piston heads, though the heat conditions there are somewhat less severe than above chemical reactions within the oil are just as inevitable and continuous No lubricating oil exists that will not undergo a chemical and naturally a physical change when exposed to the high temperatures on both sides of the pistons of automobile motors In other words, there is no motor oil known that will not deposit sediment in the crankcase A very marked difference does however exist in the rate of sedimentation of oils of good and of poor quality, used in the same motor under the same operating conditions It seems logical to conclude therefore that the rate of sedimentation must be a dependable measure of durability and efficiency

SERVICE TESTS

For the purpose of the following tests, let us assume that two yellow oils of the same viscosity say, between 200 and 300 seconds Saybolt at 100 degrees, be used.

Good Oil—Reactions —When a motor is run on the test stand or in a car for a few hours with a filtered oil of the highest quality and a sample taken for examination, it will be seen that the oil has changed from its original yellow to a grayish-blue by reflected light. After running several days it will be found that the oil has turned entirely black and become opaque. A sample drained from the motor into a long narrow tube and allowed to stand 24 hours will show a black sediment at the bottom. The oil floating above the sediment is red in color by transmitted light and is equally as serviceable as when fresh The volume of this sediment depends upon the operating temperatures of motor parts with which it has come in contact, particularly the temperature of the piston heads upon the presence or absence of mechanical defects (leaks) in the motor and upon the quality i e., degree of purity and stability of the oil used

Poor Oil—Reactions —Let a poor oil be run in the same motor under like conditions of time and temperatures and samples examined At the end of a few minutes the oil will turn to a dense and lustrous black After standing 24 hours the sample used several days will show a voluminous black sediment, several times greater than that of the good oil

Fig 12.—Proper design for good lubrication.

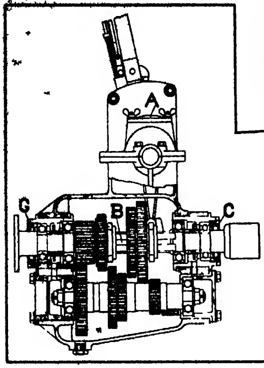
In the interpretation of these results let us assume the most favorable case for the poor oil—that the portion remaining above the sediment is still usable though more often it is not The good oil is still vastly more durable and economical than the poor (Fig 11) Chemically, this low resistance to heat shown by poor oils is again traceable to the nefarious and destructive effect of "sulpho" compounds present Regarding the probable effect which their presence might have upon the bearings and other parts within the motor, when decomposed by heat into free sulphuric acid it may be expected that corrosive action would be almost negligible The effect of hot sulphuric acid gas upon highly heated exhaust valves and seats is very noticeable, however, causing rapid pitting of the surfaces and leakage.

SUGGESTIONS RELATIVE TO DESIGN

The maximum mileage per gallon of oil in the best modern automobile motor is rarely above 1,000, as compared to that of the average motor which probably never exceeds 200 Why such a wide difference in efficiency? The answer is not hard to find. An examination of the 1,000-mile motor discloses the use of tight piston rings, large centrifugal rings on the crankshaft where it passes through the case, ample cooling fins in the pistons, vents between the crankcase chamber and the valve enclosures etc. Briefly put, cooling of the oil in this motor has been properly cared for and leakage reduced to a minimum. The result speaks for itself

To be specific regarding details of design Oil surplus can be kept out of the explosion chambers by leaving the lower edge of the piston skirt sharp and by the use of a shallow groove just below the lower piston ring (Fig. 12) Small holes are bored through the piston walls at the base of this groove and communicate with the crankcase The similarity of the sharp edges of piston skirt and piston ring to a carpenter's plane bit, making their operation plain.

Faulty piston rings are said to be [illegible] than in their [illegible] preferred with a [illegible] ring and bottom of groove, of [illegible] of piston [illegible]



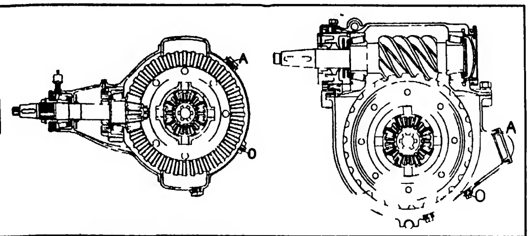


Fig 13—Proper design for good lubrication

4 inches, thin cooling webs should be provided in the head so as to fully utilize the cooling effect of the oil The ideal piston, from the viewpoint of cooling, is of course that made of aluminium alloy

The cooling of oil in the sump can be accomplished most effectively by radiating fins on its outer surface The lower crankcase should be fully exposed to the outer air A settling basin for sediment should be provided having a cubic content of not less than one tenth of the total oil capacity The depth of this basin should be at least 3 inches and its walls vertical to reduce the mixing of sediment with the oil in circulation The inlet to the oil pump should be near and above the top of the settling basin Concerning filtering screens there is little to be said, save that their areas should be ample and the mesh coarse enough (one sixteenth of an inch) to offer no serious resistance to the free flow of cold or heavy oil through them, otherwise the oil in the crankcase may build up above them to an undesirable level The necessary frequency of draining and flushing out the oil sump differs greatly with the age (condition) of the motor and the suitability of the oil used In broad terms, the oil sump of a new motor should be thoroughly drained and flushed with kerosene at the end of the first 200 miles, next at the end of 500 miles and thereafter every 2,000 miles

Now, to answer a leading question that cannot be passed over lightly, namely "What is the best type of lubricating system for automobile motors?" Without hesitation I would say force feed, i e, a circulating system with feed under pump pressure to all crank and camshaft bearings This system furnishes a copious supply of oil for carrying away the friction heat of bearings and for cooling the piston heads In fact, the large body of oil in constant circulation offers the best conveyance for surplus heat to the outer air Once the oil sump has been filled, no further attention is required There is no danger of burning out bearings or scoring cylinders from lack of oil, fouling of plugs or carbon troubles. Furthermore, so long as there is water in the cylinder jackets and oil above the oil pump inlet, no amount of punishment by hard work on the road or high motor speed can injure any of the moving surfaces in contact

TRANSMISSION AND REAR AXLE.

In the early days grease of medium-consistency was thought to be the only proper lubricant for use in transmission and rear axle mechanisms (Fig. 13), but improvements made in the design of different devices for retaining the lubricants where the drive-shafts pass through the case have fortunately made possible the introduction of more efficient semifluid lubricants.

CHEMICAL CONSTITUENTS OF TRANSMISSION LUBRICANTS.

Cup Grease.—Cup grease is manufactured, first, by the saponification of fatty oil with calcium hydroxide [illegible] in the presence of water. When saponification is complete, hydro-carbon oils are added to the soap formed by [illegible] known as cup grease. Light, medium and hard greases are readily made by varying the quantities of the constituents. [illegible]

tion of fatty oil with sodium or potassium hydroxide in the presence of water When the saponification is completed, all of the water is boiled out and a hydro-carbon oil is then added Variation in the quantity of the constituents makes possible the manufacture of light, medium and hard grease This grease when heated up becomes entirely fluid and upon being allowed to cool returns approximately to its former consistency

Graphite Grease—Finely divided graphite is mixed with cup grease to form different grades of graphite greases

Semi-fluid Oils—These are made in the same manner as cup greases the only difference being that a smaller quantity of saponified fatty oil is combined with the hydro-carbon oil

Gear Compounds—The so-called gear compounds are generally manufactured by blending fiber grease with a hydro-carbon oil Inferior grades are made from a mixture of paraffin wax and heavy oil Paraffin not being a lubricant the lubricating efficiency of such compounds is therefore reduced in proportion to the quantity present

Transmission Oils—These oils consist either of a heavy straight cylinder stock (hydro-carbon oil) or of a blend of same with a small percentage of fatty oil and are used for the most efficient lubrication of both transmission and worm- and bevel-gear rear-axle mechanisms For the lubrication of worm-driven rear axles chemically pure castor oil is sometimes used in spite of the fact that it offers no noticeable advantages over transmission oils and in the face of an almost prohibitive cost

LIMITING CONDITIONS OF OPERATION

Doubtless were it not for the frequent serious leakage of lubricant which occurs from the average commercial transmission or rear axle no other medium would be used than transmission oils The best body of these oils for use in both winter and summer lies around 140 seconds at 212 degrees (Saybolt universal instrument) Leakage does nevertheless occur and is consequently one of the chief factors if not the leading factor governing the specification of lubricants for these mechanisms It is generally recognised to-day that even a medium cup grease is unsatisfactory because of the fact that the gears cut tracks into its body thus preventing anything more than momentary contact with their teeth and the other parts requiring lubrication On the other hand a thin oil rapidly leaks out through the joints of the case and along the shafts As a solution a compromise lubricant is chosen which offers the least resistance to movement and shows a minimum loss from leakage Often a heavy grease mixed with wood fiber, asbestos or other solid matter, is used to suppress the irritating noise of poorly cut gears Such substances cannot fail to show a material loss in power transmission and are not to be advised

When cup greases are used alone, the friction heat soon causes a voluminous foaming and, later, a permanent separation of the oil from the soap which occludes it For this reason cup greases should never be used for transmission or rear axle lubricants in any other form than semi-fluid oils For leaky cases gear compounds only should be used due to their high adherence good lubricating properties and slight tendency to leakage They may be had in consistencies sufficiently heavy to suit conditions of the leakiest case without possessing any of the disadvantages of straight cup or fiber greases Leakage with any lubricant can be reduced to a minimum by the application of centrifugal rings to all shafts or if the space be too limited for the application by felt packing and by providing air vents at the top of the case so as to maintain atmospheric pressure above the lubricant within the case All lubricants possess a fairly high coefficient of expansion and when filled cold up to the center of the shafts will be expanded by friction heat and the level raised thereby to such an extent that the hot air above also expanded will force them out even through tight joints

As to the necessary frequency of inspecting the level of the lubricant in transmission and rear axles or of draining and flushing out same it would be merely a waste of words to give any definite figures There are entirely too many variables involved Suffice it to say that reasonably frequent attention should be given to maintain a uniform level in these mechanisms and to drain them whenever a sample of the lubricant shows the presence of considerable metallic dust when examined by reflected sunlight A thorough cleansing of the case between every three to five thousand miles will richly repay what it costs in lubricant by the increased life of the parts

CHASSIS

Cups Commercial cup grease of a grade suiting the season should be used exception being made only of the grease cups feeding the water pump bearings and glands where graphite greases give better service

Steering Gear The worm and sector in the steering gear housing require a cup or fiber grease or a heavy gear compound depending upon the tightness of the housing Preference should be given the latter wherever its use is possible

Wheels—With anti friction bearings a medium grade of fiber grease will give entire satisfaction In case the wheels are fitted with plain bearings a suitable grade of semi fluid oil should be used

Suspension Springs The blades of suspension springs where they come into contact with each other can be

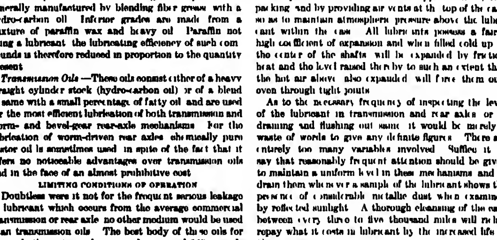


Fig. 14.—Suggested form for lubrication chart, letters designate parts to be supplide with grease at fixed intervals of time or distance traveled. Numerals designate parts to be supplied with oil.

lubricated most effectively by painting their surfaces with a heavy graphite grease. One application only will be necessary between annual overhauls; the improvement in the riding qualities of the car cannot fail to be appreciated.

Moving Parts Exposed to Dust.—Miscellaneous moving parts exposed to dust can best be lubricated by the application of a suitable grade of graphite grease.

CONCLUSION

There is no valid reason why much greater economy and efficiency of lubrication cannot be attained in all automobile motors by the simple application of a knowledge of cause and effect of oil distribution. Neither is there any insurmountable difficulty in the way of suppressing useless and costly leakage from all automobile mechanisms. Certainly the almost unbelievable drop in yearly maintenance costs and the total elimination of all lubrication annoyances should make the study and successful solution of this problem one of absorbing interest and profit to every manufacturer and to his customers. Intelligent co-operation between oil refiners and automobile manufacturers would surely do much along this line.

Measuring Growth of a State

First Enumeration Solely to Provide for Political Reapportionment

The census enumeration of New York State promises to be next to that of the United States the largest and most expensive single statistical enterprise in the country. In no other State are there so many people to be enumerated, while the fact that the number and complexity of the interrogatories will be more extensive this year and a completion within the short space of two months set by the Constitution is necessary, a large number of supervisors and enumerators, clerks and interpreters will be required.

The task in its simplest phase involves the counting of upwards of the 11 millions of inhabitants now estimated to be in this State.

FIRST STATE CENSUS IN 1782

Under the first State Constitution a census was taken in 1782, when the Sheriff was required to direct the local constables to take the number of white inhabitants, including refugees, victims of the invasion of the enemy, at the expense of the counties. These returns were to be summarized and filed with the Secretary of State, to be transmitted by him to Congress. A similar enumeration was taken again in 1786, but it was not until the third State census was taken in 1795 that the law required the Secretary of State to prepare the blanks containing the questions covered by the enumeration. This State first inaugurated the decennial or periodical system of enumeration of the population and resources. In order not to conflict with the Federal system, the State Constitution provided that an enumeration could be taken in the years in which the unit figure five was present.

During the colonial period the provincial governors were required to give account of the progress of the settlements, and in New York colony at least fourteen different counts of population were taken before the Revolutionary War. Since the provision for periodic measurements of the State's growth was inaugurated by the framers of the first Constitution, many foreign countries, States and Territories have adopted similar systems, and at the present time the laws of at least two foreign countries require an enumeration of the population every five years.

BASIS OF POLITICAL REAPPORTIONMENT

The first census enumeration in New York State was intended solely for political reapportionment. Consequently the electoral census of 1782, 1786, 1790, 1795, 1801, 1807, 1814 and 1821, taken under the constitutional provision of 1777, limited the scope of such inquiries; in fact, the first three of these were for the counts of these electors distributed into four property classes. The census of 1914, however, was the first to depart from this rule of mere enumeration of the electors and to procure other social information. At that time over a dozen inquiries were added concerning property qualifications, age, sex, number of slaves, etc.

The census of 1821 required additional inquiries, including agricultural and manufacturing questions and other matters considered of relative importance at that time. In 1825 other questions were added to the census of that year, which was the first to be taken under the second Constitution of 1821. These inquiries concerned the enumeration of defective and dependent classes, such as the deaf, dumb, blind, insane and paupers, and since that time care has been taken to obtain information concerning physically and mentally defective classes. Another item included marriages, births, deaths, and in the next census of 1835 little change was made in the scope of this inquiry excepting that certain questions were added concerning the factory and manufacturing interests.

TRADE INQUIRIES INCREASE

The census of 1845 introduced many inquiries concerning trade commerce, newspapers and periodicals. It increased the number of questions relating to agricultural interests. The census of 1855 under the third Constitution of 1846 differed radically from all previous ones in that for the first time the Secretary of State was called upon to undertake the direction of all the work. In the previous enumerations the returns were tabulated by the local enumerators, who were required to report the totals to the county clerk, who in turn forwarded a summary to the Secretary of State's office.

The next two censuses were taken in 1865 and 1875, when the enumerators acting in the places of the marshals were called upon to count the population. These census takers were allowed $3 per day, to be paid by the county, and this was the last occasion in which the census was taken at the entire expense of the locality, although the State at that time contributed $62,555, while at the census of 1875, the first to be undertaken by the State alone, the appropriation was doubled, totalling $138,037. The census of 1865 provided for a large number of inquiries concerning soldiers and sailors engaged in the Civil War. There was opposition against the enumeration because of the fear that such information would be used to draft soldiers. In 1885 and 1895 no census was taken, although in 1892 a mere count consisting of seven questions on population was made, when an appropriation of $205,000 was allowed. Since the publication, however, of the last census taken in 1905, the importance of the subject has been more fully recognized, and the amount of attention paid to the census cannot be better shown than in the figures for the number of inquiries made since this last census.

The constitutional provision limiting the time during which census returns are to be made has frequently proved to be insufficient to complete the task, though it is expected that the coming enumeration can be completed within the months of May and June, as the Constitution requires. The system usually adopted in this country of extending the period of enumeration over one month has been termed the census *de jure* as compared with the English system, which is called the census *de facto* method, which latter system begins and completes the enumeration within one day after a previous distribution of the blanks to be filled out by each householder. Such a method, while reducing the number of errors caused by duplication to the minimum, could not be employed in this country because many sections are thinly populated and difficult of access.

As stated, census enumerators originally were the local constables. Later the law provided for special takers who were called "marshals" and appointed by the Secretary of State. At the present time these individuals are called supervisors and enumerators, and the law now provides that the Secretary of State shall appoint and prescribe their duties and have direct control over their work. Circulars of instructions are provided, and all returns are to be tabulated and arranged according to the numbers of inhabitants, exclusive of aliens, and the number of aliens in each village, town, county, city, borough and the ward of the State.

MACHINE TABULATION

Tabulating to-day's population statistics within a reasonable length of time would be practically impossible were it not for the modern machine methods necessary for tabulating the different characteristics of the population for which inquiries are made and which must be presented in various combinations with one another. By the method now in vogue all the numerous facts appearing upon the schedules are transferred to the cards, each being represented by a punched hole, the significance of which is determined by its location on the cards, which are run rapidly through tabulating machines to register the data in a variety of combinations.

With this mechanical aid it is possible to complete the tabulation of all the data within the time specified by law. The Constitution in about one half of the States requires the enumeration of the population every ten years, but less than half of the States completed this work in 1905. The original returns of the enumerators during the past century were deposited in the State library, but unfortunately these were destroyed in the fire of 1911, although the summaries made from these returns are now on deposit in the office of the Secretary of State.—*N. Y. Post.*

Porous Boiler Settings

The heavy brick setting of a steam boiler looks so solid and substantial that not only is the average user of steam deceived as to its ability to keep out air, but the expert who should know better has his attention easily diverted from a very important feature in successful boiler operation. To insure efficient and economical operation all air reaching a boiler furnace should be admitted at the proper place and in the proper quantities, if economical combustion of the fuel is to be secured, and any additional air that finds its way into the furnace through casual entrances simply interferes with both the draught and the proper combustion. It has come to be recognized that brick boiler settings are by no means airtight, but are actually decidedly porous; and this fact was recently visibly demonstrated at an electric power plant in the Middle West. Men were set at work painting a boiler setting with extra heavy stack paint, and before one side had been covered an improvement in the draught could be seen at the draught gage. When both sides had been painted the natural draught had increased by 0.15 inch.

That this point is so commonly overlooked is not surprising when we constantly see the ruinously cracked brickwork around boilers that is allowed to stand year after year without attention.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, JUNE 26th, 1915

Published weekly by Munn & Company, Incorporated. Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer; all at 233 Broadway, New York

The Scientific American Publications

Scientific American Supplement (established 1876) per year	$5.00
Scientific American (established 1845)	3.00
American Homes and Gardens	3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check.

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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